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*Chris Warren*  
DOCUMENT CONTROL ADMINISTRATOR

INSTRUCTION MANUAL

Models 5442 to 5446  
DUAL PRESET COUNTER

Lot 6 and above

**LeeMark Associates**  
CONTROL - INSTRUMENTS - INDICATING  
P. O. Box 8467 Kansas City 14, Mo.  
Nlagara 2-3313

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Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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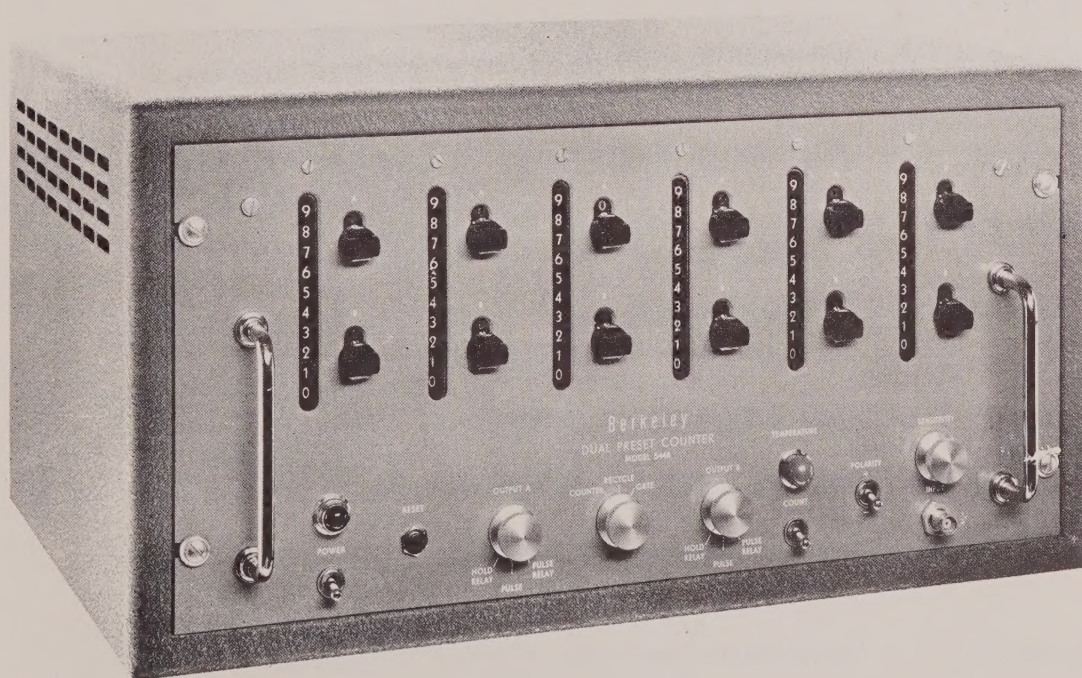


Figure 1 Berkeley Double Preset Counter

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# 1 Introduction

## DESCRIPTION

The Berkeley Dual Preset Counter is a high speed electronic counter from which output information may be obtained at any two counts up to the maximum capacity of the unit. Any discrete series of physical events that can be represented by a fluctuating voltage can be counted. Various transducers such as photocells, magnetic pickups, or switches, may be used to provide an output for counter operation.

Owing to its simplicity and flexibility of design, this is an ideal instrument for production control. Many processes may be automatically controlled by the two output signals. Two independently variable delays or two different alarms can be obtained at the two preset counts. For instance, in coil winding the driving motor can be slowed a predetermined number of turns before the final turn.

## SPECIFICATIONS

|                    |                                                                                                                                                                                                                                                                                                                                 |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Counting Capacity  | 5442, 1-100; 5443, 1-1000; 5444, 1-10, 000; 5445, 1-100, 000; 5446, 1-1, 000, 000.                                                                                                                                                                                                                                              |
| Frequency of Count | d-c to 40, 000 cps.                                                                                                                                                                                                                                                                                                             |
| Input Sensitivity  | Pulse of at least $\pm 1$ volt peak with respect to ground and 2 microseconds duration. For d-c level changes, fluctuation must intersect ground level and exceed one volt level of either polarity. A blocking capacitor must be inserted between the signal source and J101 for any input which doesn't pass through 0 volts. |
| Input Impedance    | 1 megohm shunted by 40 $\mu\text{mf}$ .                                                                                                                                                                                                                                                                                         |
| Power Requirements | All models, 105-130 volts, 50-60 cps a-c.<br>Model 5446            250 watts<br>Model 5445            225 watts<br>Model 5444            200 watts<br>Model 5443            180 watts<br>Model 5442            160 watts                                                                                                        |

|                  |                                        |
|------------------|----------------------------------------|
| Accessory Socket | 10 pin connector                       |
| Relay Contacts   | 14 pin connector                       |
| Input Jacks      | Front and rear                         |
| Digital Recorder | Socket available                       |
| Dimensions       | 20-3/4" wide x 10-1/2" high x 15" deep |
| Weight           | 65 lbs. approximately                  |

#### ACCESSORIES

The following instruments can be used in conjunction with the Dual Preset Counter. For specific details, we invite your inquiry.

Model 441 Photocell and Light Source - Reflecting system, 100 cps to 20 Kc.

Model 442 Photocell and Light Source - Reflecting system 0 to 5 Kc.

Model 450 Photocell with Model 455 Light Source.

Model 504 Stylus Pickup.

## 2 Operation

### INSTALLATION

The Dual Preset Counter requires no special installation procedure. It may be operated in any well ventilated location. The unit is designed to operate from an a-c power source of 117 volts, 50-60 cps. Satisfactory operation may be expected from 105 to 130 volts. Models 5442, 5443, 5444, 5445 and 5446 consume 160, 180, 200, 225, and 250 watts of power, respectively.

### OPERATION

According to the position of the function control, the Dual Preset Counter will perform one of three functions. In each case, independent outputs are available from each channel. In the COUNTER position, the instrument functions as a high speed electronic counter generating one output pulse each time the first preset number (A) is reached and a second at full capacity. In the RECYCLE position, outputs are available when the second preset number (B) is reached as well as the first, the former resetting the instrument and indefinitely repeating the cycle without losing a count. In the GATE position, the instrument counts until the second preset number is reached, then the input to the Decimal Counting Units is gated off. Again, outputs are generated at the two preset numbers. The second number is displayed until the RESET button is pressed or pins D and F of the accessory socket (J202) are shorted.

Three types of outputs are available from each channel, PULSE-RELAY, PULSE, and HOLD-RELAY. Inasmuch as the channels are independent, the output selected for one channel can differ from the other. The two outputs are also available at the accessory pins G and H respectively of J202 as a voltage level change of -35 V to +10 V.

In the PULSE position, with the multivibrator (V106) used as a one-shot, a pulse of 45 volts amplitude, 3  $\mu$ sec rise time, 1  $\mu$ sec decay time, and 12 to 150  $\mu$ sec duration is generated. In the PULSE-RELAY position, the duration of the pulse may be varied from 0.02 sec to 0.25 sec. The normally closed relay in each channel de-energizes during the output pulse interval. In the HOLD-RELAY position, with the multivibrator used as a binary, either voltage level is held for a duration dependent on the two preset counts and the SINGLE-DUAL switch for output A. The relay is released and re-energized each time the binary changes state, as indicated by a change in output voltage level.

When PULSE and PULSE-RELAY outputs are chosen, a pulse is generated in each channel when its particular count is reached, yielding coincidence. In HOLD-RELAY, each binary changes state when its respective count is reached except when the SINGLE-DUAL switch is in DUAL. The first coincidence triggers the A binary, and the second triggers both binaries, returning A to its normal state and leaving B in the abnormal state. For example, if the instrument is recycling, the A binary is triggered twice during each cycle while the B binary changes state each cycle.

The unit leaves the factory with the switch (located on chassis) in the SINGLE position. The DUAL position should be used only if the A output is HOLD-RELAY.

As a fail-safe scheme, the relays are normally latched in the reset condition of the unit. A power failure releases all relays. Relay connections, available at the 14 pin connector on the rear of the chassis, should be made with this feature in mind.

When the internal temperature exceeds 160°F (70°C), the TEMPERATURE lamp will light. Prolonged operations at high temperatures causes rapid deterioration of components.

To operate the Dual Preset Counter (see Figure 1 and Table 2).

1. Connect power cable and turn on POWER and FAN switches.
2. Place the POLARITY switch in position corresponding to polarity of input applied.
3. Select the proper function, COUNTER, RECYCLE, or GATE.
4. Connect INPUT jack directly to signals to be counted if its d-c level is at ground level, or in cases of d-c level changes, the ground level is crossed. Otherwise a suitable blocking capacitor is required.
5. Turn on COUNT switch and turn the SENSITIVITY control clockwise just beyond the point where the instrument will properly count the input pulses.
6. Preset the lower number in row A of switches and select type of output desired for this channel; PULSE, PULSE-RELAY, or HOLD-RELAY (see Table 1 and Figure 2).
7. Preset second number in B switches and select output for this channel.
8. Push RESET button if GATE or COUNTER functions are chosen.

TABLE 1  
Output Combinations  
Dual Preset Counter

Single Operation.

|   | Output A | Output<br>Characteristic | Output B | Output<br>Characteristic |
|---|----------|--------------------------|----------|--------------------------|
| 1 | P-R      | I                        | P-R      | IV                       |
| 2 | P-R      | I                        | P        | IV                       |
| 3 | P-R      | I                        | H-R      | V                        |
| 4 | P        | I                        | P-R      | IV                       |
| 5 | P        | I                        | P        | IV                       |
| 6 | P        | I                        | H-R      | V                        |
| 7 | H-R      | II                       | P-R      | IV                       |
| 8 | H-R      | II                       | P        | IV                       |
| 9 | H-R      | II                       | H-R      | V                        |

Dual Operation

|    |     |     |     |    |
|----|-----|-----|-----|----|
| 10 | H-R | III | P-R | IV |
| 11 | H-R | III | P   | IV |
| 12 | H-R | III | H-R | V  |

Legend:

H-R Hold relay

P pulse

P-R pulse-relay

Note: Figure 2 shows output characteristics  
of each channel

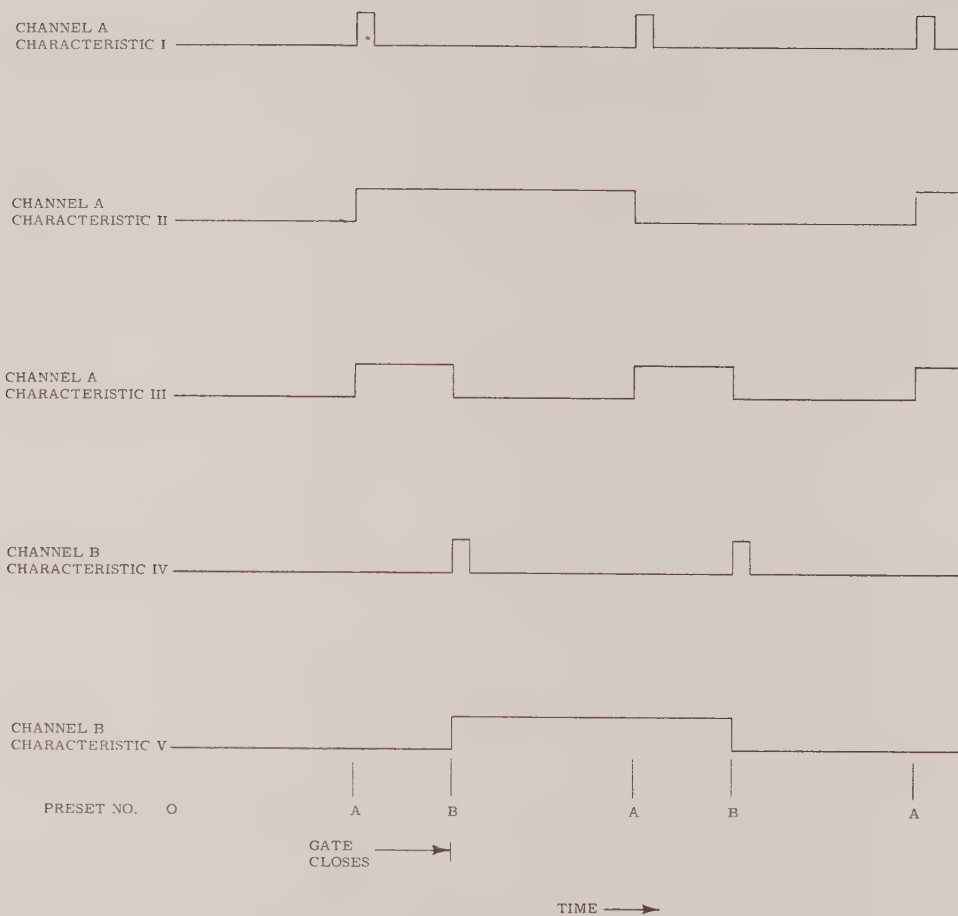


**Figure 2 Output Characteristics**

## PROPER OPERATION OF RELAYS

Contacts are rated at 5 amperes 115 volts, 60 cycles, non-inductive load. Reliable operation of this relay may be expected up to a rate of 25 operations per second. To reduce arcing across the relay contacts and eliminate stray counts, an absorption circuit formed by a series connected resistor and capacitor shunted across the contacts may be necessary. Place this circuit immediately adjacent to the relay terminals wherever possible.

Component values, a function of the open circuit voltage across the contacts and the steady current of the external load, should be determined empirically. The capacitor should be large enough to minimize arcing when the contacts open, but not so large that contacts are latched when another relay is energized. The resistor should be just sufficient to limit the capacitor discharge current during closure and minimize contact pitting.

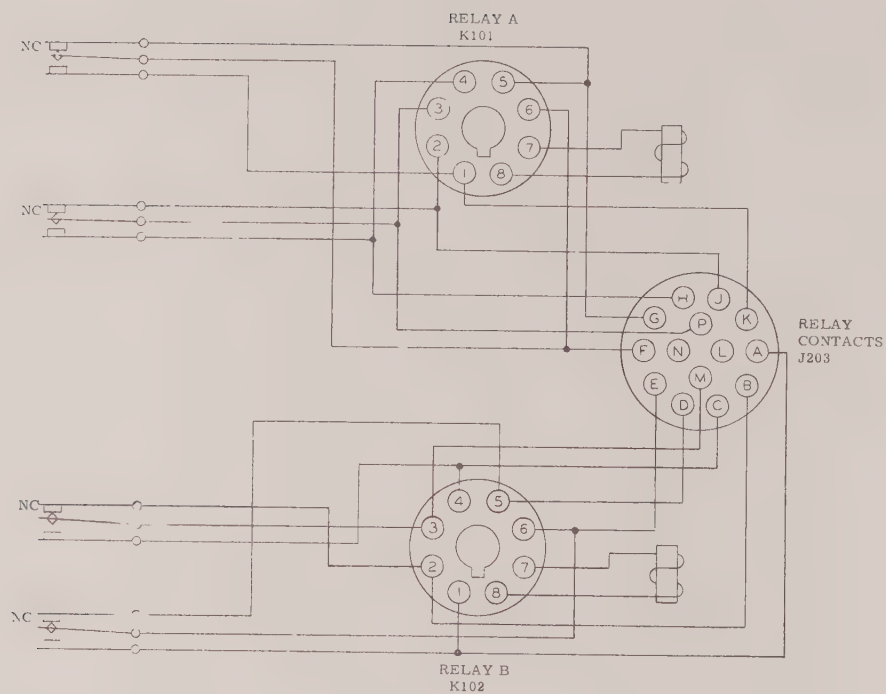
Three specific applications are listed below to indicate orders of magnitude for the components. Two different networks are listed for each application. (see Figures 3 and 4).

|                                                        | #1                             | #2                             |
|--------------------------------------------------------|--------------------------------|--------------------------------|
| Electro-Mechanical Register<br>117 volts a-c 0.18 amp. | 0.02 $\mu$ fd.<br>100 $\Omega$ | 0.1 $\mu$ fd.<br>100 $\Omega$  |
| Relay, 117 volts a-c, 0.06 amp.                        | 0.02 $\mu$ fd.<br>100 $\Omega$ | 0.07 $\mu$ fd.<br>270 $\Omega$ |
| Motor Control Relay<br>117 volts a-c, 0.25 amp.        | 0.8 $\mu$ fd.<br>100 $\Omega$  | 1.2 $\mu$ fd.<br>100 $\Omega$  |

## MODIFICATION A

Modification A adds a high-speed mercury-contact relay for operations up to 100 cycles per second. Accordingly, the PULSE WIDTH adjustment of both channels has been changed to provide a 4 to 100 milliseconds range.

A Western Electric 275B mercury-contact relay has been added. The maximum operating speed is determined by the number of ampere-turns in excess of those necessary to operate the relay. One hundred and eighty turns are required to operate the relay, leaving an excess of 200 in this application.



SWITCH ARRANGEMENTS SHOWN FOR UNENERGIZED RELAYS. HOWEVER, IN PRESET COUNTER, RELAYS ARE NORMALLY ENERGIZED UNTIL PARTICULAR PRESET COUNT IS REACHED.

**Figure 3 Standard Relay Connection Diagram**

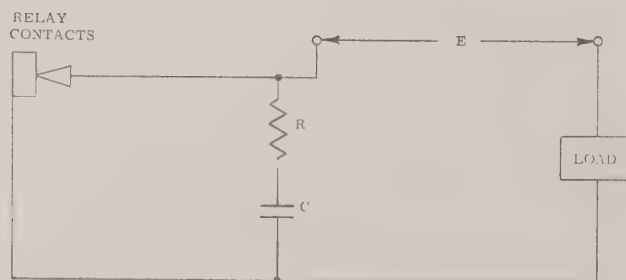


**Figure 4 Absorption Network**

Total current through the four stationary front and back contacts should not exceed 5 amperes rms on a continuous basis. In addition, for long service life, the following ratings apply:

1. For any single contact within the relay the current immediately prior to opening should not exceed 5 amperes.
2. The voltage across the contacts immediately prior to closing should not exceed 500 volts.
3. The product of current at opening and voltage at closing as described above should not exceed 250 volt-amperes. This condition defines the current-voltage relations permissible for currents less than 5 amperes in the voltage range from 50 to 500 volts.

Absorption Circuit. For the absorption circuit, the preferred values of R and C can be determined by the following equations, except where indicated below:

$$C = \frac{I^2}{10} \text{ microfarads} \quad (A)$$

$$R = \frac{E}{10I(1 + 50/E)} \text{ ohms} \quad (B)$$

Where I = load current in amperes immediately prior to opening of contacts. E = source voltage immediately prior to closing of contacts.

The calculated value of C is required in all cases, if E is less than 50 volts, and I less than 2.5 amperes, R may be omitted. For all other conditions, R shall be determined by equation (B) but must not be less than 0.5 ohms.

For E up to 70 volts, R may be three times value in (B).  
For E at 100 volts, R shall be within  $\pm 50\%$  of value in (B).  
For E at 150 volts, R shall be within  $\pm 10\%$  of value in (B).  
For E greater than 150 volts, equation (B) should be followed closely.

Load and Wiring Protection. The "break" action of this relay is extremely rapid, resulting in very large peak voltages across the load. For protection of the load and circuit wiring, these peak voltages can be reduced to safe levels by increasing C in equation (A) above the minimum value required for contact protection. The

appropriate value can be determined by measuring peak values within the first few milliseconds after break of the contacts.

Characteristically, when these relays are operated at rates of less than one per second, all four stationary contacts and the armature may be electrically connected during the transfer of the armature from one pair of stationary contacts to the other. This "bridging" of the contacts is caused by the wetting action of the mercury. If "bridging" occurs, it should not last more than a millisecond. If the application of this relay involves a source of power across the front and back contacts, fulfill the contact protection requirements and do not exceed current ratings. In some cases, a current limiting impedance in the power circuit may be required.

Temperature Limits. The maximum ambient temperature is determined by the melting point of the compound used in the relay assembly. At an ambient of 100°F, the total power dissipation in the operating coil and switch assembly must not exceed 2 watts continuously. At higher ambient temperatures, operation is permissible with lower power dissipation in the relay. The steady state temperature rise is approximately 35°F per watt of total dissipation in the operation coil and switch assembly. An internal temperature of 170°F must not be exceeded.

Mounting Position. Optimum performance is obtained when this relay is operated in a vertical position. Somewhat decreased performance is obtained for operation at small angles off the vertical position. The drive on the operating winding as well as the departure of the relay mounting position from a true vertical position affect the "bridging-transfer" time of this relay. Mounted at an angle other than vertical, the departure should not exceed 30 degrees from the vertical. Under such conditions, and for operating rates of less than one per second, any "bridging" should not last more than one millisecond.

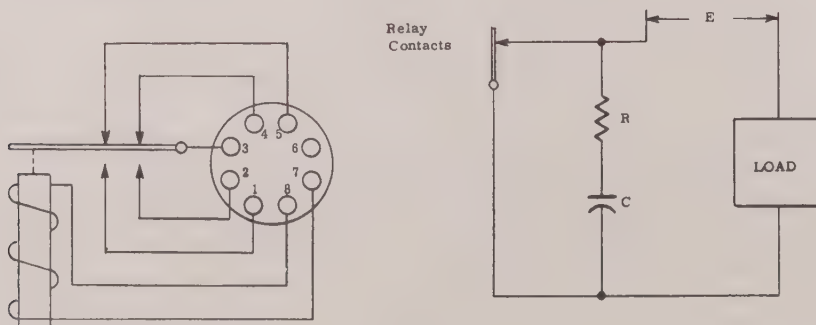


TABLE 2

Control and Connector Functions

| <u>Control or Connector</u>                      | <u>Detail No.</u> | <u>Component</u>                 | <u>Function</u>                                                                |
|--------------------------------------------------|-------------------|----------------------------------|--------------------------------------------------------------------------------|
| POWER                                            | S201              | Front Panel DPST Toggle Switch   | Applies line voltage to instrument when ON, as indicated by green pilot light. |
| RESET                                            | S106              | 3 PST Pushbutton, NC             | Reset all DCU's and output binaries.                                           |
| PULSE-RELAY<br>PULSE, HOLD-<br>RELAY of OUTPUT A | S107              | 4-Pole, 3 Position Rotary Switch | Selects type of output information first preset count is reached.              |
| COUNTER,<br>RECYCLE, GATE                        | S102              | 3 Pole, 3 Position Rotary Switch | Selects desired function of instrument when second preset count is reached.    |
| PULSE-RELAY<br>PULSE, HOLD<br>RELAY of OUTPUT B  | S103              | 4 Pole, 3 Position Rotary Switch | Selects type of output information when second preset count is reached.        |
| TEMPERATURE                                      | I202              | GE #47 Lamp                      | Lights when internal temperature exceeds 160° F or 70° C.                      |
| COUNT                                            | S105              | SPDT Toggle Switch               | Allows instrument to count when ON. When OFF, instrument will never count.     |
| POLARITY                                         | S101              | SPDT Toggle Switch               | Selects the desired polarity.                                                  |

| <u>Control or Connector</u> | <u>Detail No.</u> | <u>Component</u>                         | <u>Function</u>                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------|-------------------|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SENSITIVITY                 | R101              | 1 M, 2 watt Potentiometer                | Adjusts sensitivity of instrument by attenuating the input amplitude.                                                                                                                                                                                                                                                                                                                                  |
| INPUT                       | J101              | Type BNC Connector UG-290/U              | Connector for input source.                                                                                                                                                                                                                                                                                                                                                                            |
| INPUT                       | J204              | Back Chassis Type BNC Connector UG-290/U | Connector for input source.                                                                                                                                                                                                                                                                                                                                                                            |
| ACCESSORY                   | J202              | AN 3102A-18-1S                           | Ten-pin connector with the following connections for operating external apparatus.<br><br><div> Pin<br/> A ground<br/> B no connection<br/> C -150 volt regulated, 5 am.<br/> D external reset, short A to pin F<br/> E filament, 6.3V<sub>a</sub> at 5 ma<br/> F 300V, regulated, 20 ma<br/> G d-c output, channel A<br/> H d-c output, channel B<br/> I filament, ground<br/> J no connection </div> |
| DIGITAL-RECORDER (optional) | J205              | AN 3102A-18-12S                          | Connector available for operating Berkeley Recorder systems.                                                                                                                                                                                                                                                                                                                                           |

| <u>Control or<br/>Connector</u> | <u>Detail<br/>No.</u> | <u>Component</u>                                                                           | <u>Function</u>                                                                                                     |
|---------------------------------|-----------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| RELAY<br>CONTACTS               | J203                  | AN 3102A-22-19P;<br>AN 3102A-22-19S<br>(coupling mate) with<br>AN 3057-12A cable<br>clamp. | Connector to relay contacts<br>of both output channels. Pin<br>connections indicated in relay<br>operation section. |
| FAN                             | S202                  | DPST Toggle Switch                                                                         | Connects fan to line voltage<br>when ON.                                                                            |
| 117VAC                          | J201                  | Recessed three-<br>pronged plug                                                            | Receptacle for power cord.                                                                                          |

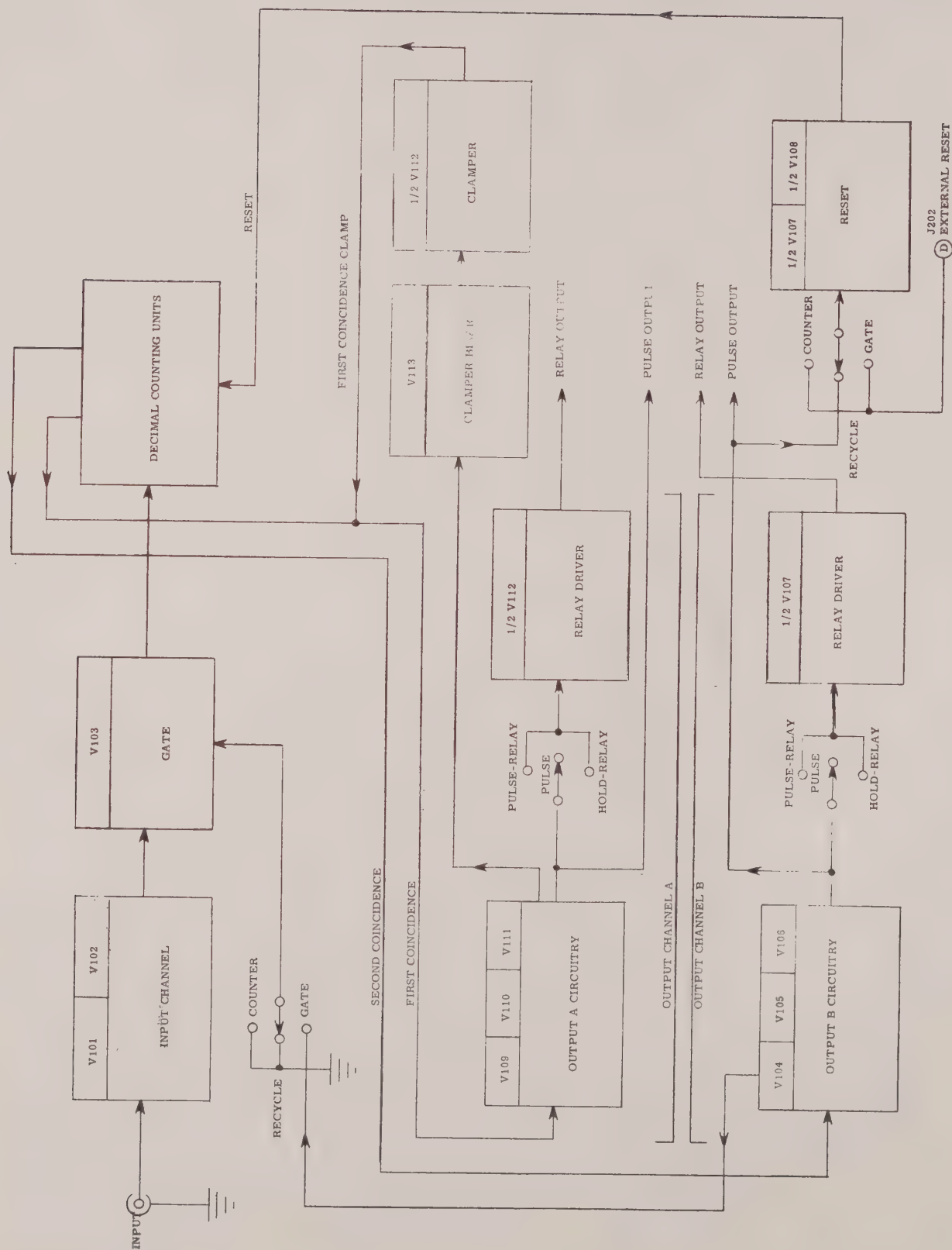


Figure 6 Functional Diagram

# 3 Theory

## BASIC DESIGN

Basically, the Dual Preset Counter consists of an input circuit, an electronic gate, a system of cascaded dual-presettable Decimal Counting Units, and two identical output channels. A variation in voltage is applied to the input circuit, amplified, shaped and sent to an electronic gate. Opening the gate passes the incoming count to the first of the cascaded DCU's. At the first preset count, output information is derived from the first coincidence system. On the second preset count, the output from the second coincidence system initiates various electronic operations, e.g., resetting the DCU's actuating a relay circuit and/or closing an electronic gate.

## INPUT CIRCUIT

A phase inverter (V101) and Schmitt Trigger (V102) amplify and shape the input pulses. The phase inverter amplifies, and in conjunction with the polarity switch, sends positive pulses to the trigger circuit which provides voltage discrimination and a standard output.

Equal voltages on both plates of the phase inverter are maintained by a cathode adjustment (see Figure 7), resulting in an extremely stable circuit which requires no specially selected tube. Balancing the voltage seven volts below the trigger voltage of 143 volts assures triggering of the Schmitt Trigger with a rising voltage without respect to the polarity of the input pulse. Properly adjusted, the plate voltages will indefinitely stay within a volt or two of each other.

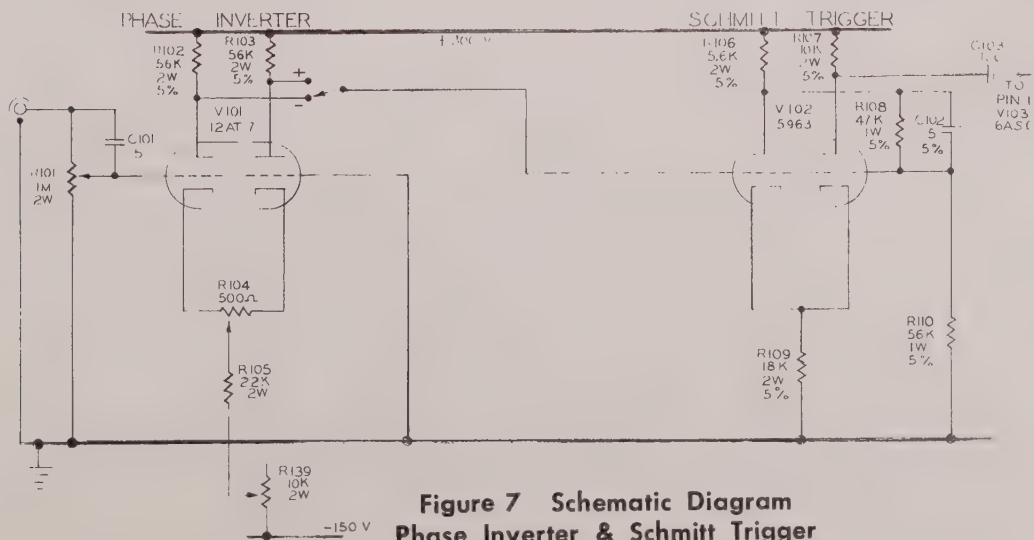


Figure 7 Schematic Diagram  
Phase Inverter & Schmitt Trigger

The plates of the phase inverters are alternately d-c coupled to the input grid of the Schmitt Trigger through the POLARITY switch (see Figure 7). The triggering, detripping, and hysteresis voltages are 143, 140.5 and 2.5, respectively. An output swing of 75 volts is obtained across the plate resistor, R107, with rise and fall times of about 1.5 microseconds.

Electronic Gate. The output of the trigger circuit is R-C coupled to the control grid of the 6AS6 (V 103), and dual-control pentode biased beyond cut-off. A 100 volt negative output pulse from this stage drives the first DCU. With the function switch set at GATE, the second coincidence closes the gate and cuts off the drive to the first DCU because of the negative bias on the suppressor grid. This prevents conduction regardless of the control grid voltage. The second preset count is displayed until the RESET button is pushed or the unit is externally reset. Set a RECYCLE or COUNTER, the function switch grounds the suppressor grid, holding the electronic gate open.

The COUNT switch is wired in series with the suppressor grid. In the OFF position, a negative voltage connected to the suppressor grid keeps the tube below cut-off. In the ON position, the gating action of the suppressor grid depends on the function of the instrument.

Decimal Counting Units. Models 5442 through 5446 differ only by the number of Model 732 Decimal Counting Units used. Wherever a DCU is removed, pins 4 and 7 of the empty socket are shorted. AY106 is removed in the Model 5445; AY101 and AY106, Model 5444; AY101, AY106 and AY 105, Model 5443; AY101, AY102, AY105, and AY106, Model 5442.

Two to six DCU's are cascaded to give the desired capacity. To complete the two coincidence systems, all the plates of one set of 5964 tubes, (pin 6 of all DCU's) are connected through R115 to the 300 volt supply, while R146 connects the plates of the other set of 5964 tubes (pin 10 of all DCU's). Prior to the occurrence of either preset count, the common plate voltages measure less than 50 V. When the A preset count is reached, all the 5964 tubes in the first coincidence system are cut-off and the common plate voltage rises to +260 V in 15  $\mu$ seconds or less. When the B preset number is reached, similar action occurs in the second coincidence system.

The Model 732 DCU is described in Appendix A.

Output Channels. Basically, the two output channels are identical. Switches and a few components are added to the second (B) to vary the function of the instrument.

Inverter-Amplifier. The positive pulse from the coincidence circuit, pin 10 of the DCU's is applied to the grid of V109A which functions as an inverter-amplifier. The ratio of the divider network, R147 and R174, is chosen so that when the coincidence plates are low, the triode is cut-off. Conversely, with a high coincidence plate voltage, the triode conducts, producing a negative transient at the triode plate. This negative transient drives the multivibrator tube, pin 1 of V111, through a diode, V110B, for PULSE and PULSE-RELAY outputs. For HOLD-RELAY operation, both diodes of V110 are driven.

One-Shot Multivibrator/Binary. As a one-shot circuit, V111 produces a standard pulse of specified duration, rise time, and amplitude whenever it is triggered. By varying the resistance of R160, the time constant of the circuit is varied, thus varying the duration of the output pulse. Such is the case for PULSE and PULSE-RELAY operation.

When binary operation is selected, the HOLD-RELAY position is used and the necessary crossover network, R157, R159 and C132 is connected and the timing network, R160, R161, and C127, is removed. Each time a coincidence output is applied to the cathodes of the diodes, V110, the binary changes state. The right hand grid resistor is returned to the reset line for manual resetting.

OUTPUT to the accessory socket is taken from pin 6 of the multivibrator tube through the divider consisting of R162, R175 and C125. Drive to the relay tube is taken from the plate with the normally high voltage, pin 1 through another divider, R163 and R176, to the grid of V112, pin 2. Normally, the relay is energized and releases when the left plate voltage (pin 1) drops because of a coincidence output.

The foregoing discussion applies to the corresponding points in channel B as well, except for the COUNTER function. Here, the multivibrator, V106, is driven by the output of the last DCU. In addition, the voltage swing of the inverter-amplifier, pin 1 of V104, is divided and applied to the suppressor grid of the gate tube, V103, for the GATE function only. Cutting-off the amplifier tube opens the gate and vice versa. The second coincidence turns on the amplifier tube and closes the gate for GATE operation.

To reset the DCU's with the instrument in the RECYCLE condition, the output at pin 6 of V106 drives a cathode follower, V107B.

Clamper Binary and Clamper. After coincidence is reached for the first preset number in the A channel, other pulses are normally

generated in the coincidence system while the DCU's continue counting. Inherently, the appearance and spacing of subsequent coincidence pulses depends on the number preset and its difference from the second preset number.

Clamping action by V112B prevents the occurrence of the above situations. The first coincidence pulse through C120 triggers the high-speed clamper-binary, V113, as well as producing an output for Channel A. The normally-low right hand binary plate voltage rises from 80 V to 240 V, a rise sufficient to raise the grid voltage of V112B above ground, causing the clamper tube to conduct. The plate voltage of the clamper triode drops to less than 50 V and clamps the first coincidence system, pin 10 of all the DCU's until this binary is reset by the second output or manual operation. Resetting returns the right hand plate of the binary to 80 V and the clamper tube is cut-off, releasing the first coincidence system.

With the SINGLE-DUAL switch in DUAL, and the OUTPUT A switch in the HOLD-RELAY position, the reset pulse drives the clamper-binary which in turn drives the A binary. This is accomplished by the right hand plate of the clamper-binary (going negative) triggering the high right hand plate of the A in binary through C110 and S104.

Cathode Follower Reset. The output from the B multivibrator, pin 6 of V106, drives a cathode-follower V107B to reset the instrument for the RECYCLE function. The positive rise overcomes the beyond-cut-off bias on the grid. The positive transient produced resets the instrument through the cathode-follower tube. The Decimal Counting Units are reset in about 12  $\mu$ sec, a period short enough to allow the instrument to reset and resume counting without missing a count. For GATE operation, external resetting is accomplished by shorting pins D and F (+300V) of the accessory socket.

When the selection of OUTPUT B is HOLD-RELAY, and the unit is recycling, V106 is operating as a binary. The first B output triggers V106 to its abnormal state and the positive transient on its right hand plate resets the instrument. The second B output returns the binary to its reset state and the right plate voltage drops while the left plate voltage rises. The latter resets the instrument through V108A, another cathode follower circuit used specifically for this situation. This cycle repeats for every two B outputs and is necessary because the multivibrators, V106 and V111, can be reset only by manual operation when connected as binaries.

Power Supply. A conventional power supply provides a regulated  $B+$  of 300 volts up to 150 MA, while an OA2 glow discharge diode stabilizes the bias supply of 30 MA at -150 volts.  $B+$  ripple is about 0.1 volt peak-to-peak.

# 4 Maintenance

## ROUTINE ADJUSTMENTS

Phase Inverter. With no input to the unit, determine the trigger level of the Schmitt circuit by varying R104 slowly until the units position DCU indicates a count. Note the voltage on pin 2 of V102 when the count is registered. Balance plates of V101 if necessary.

Output Pulse Width Adjustment. If PULSE-RELAY output is selected, the de-energized period of the relay is variable in the range of 0.02 secs to 0.4 secs by the appropriate PULSE WIDTH potentiometer. Coarse adjustment can be made by observation, though an oscilloscope or time interval meter must be used for finer setting.

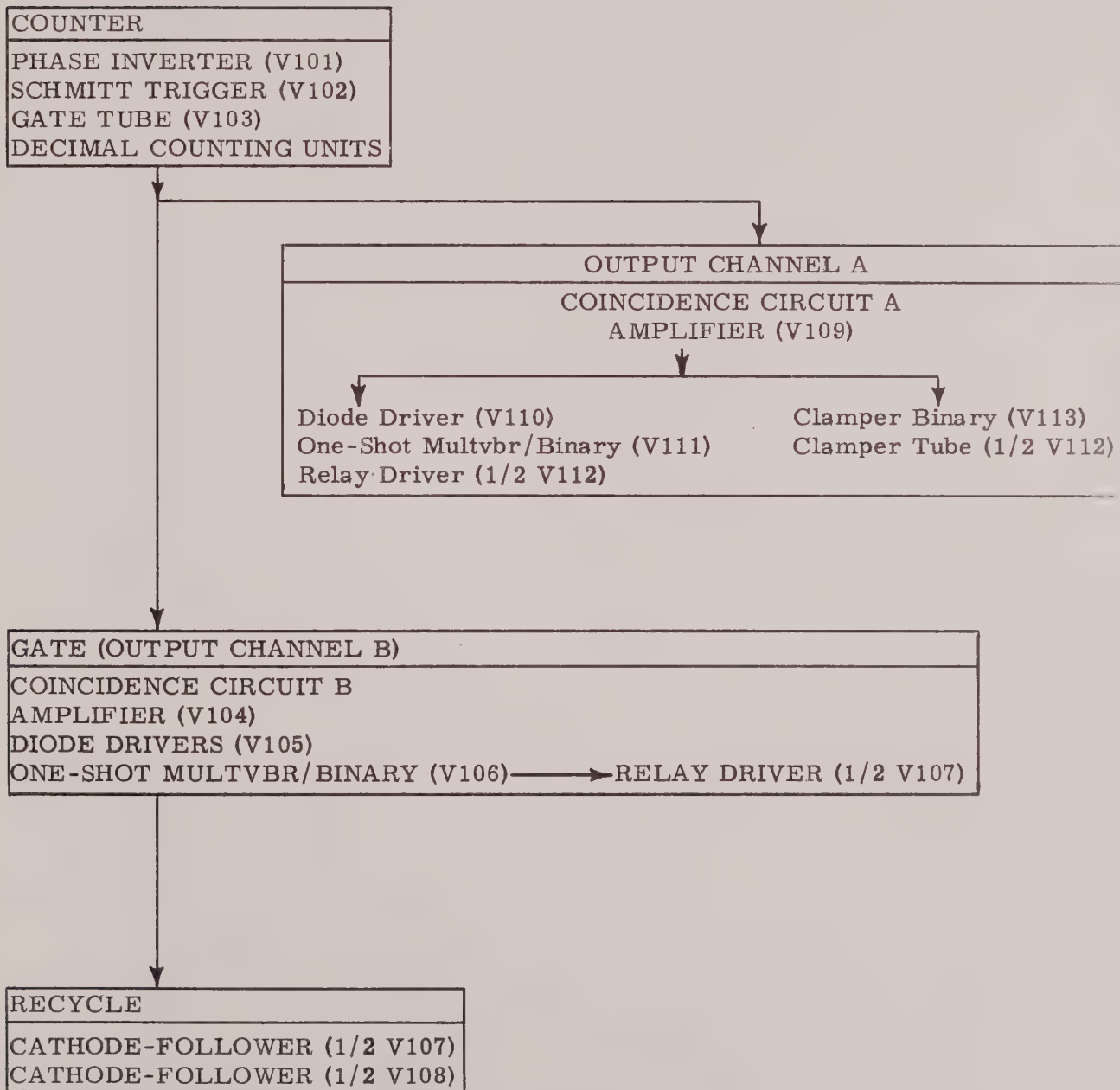
## SERVICING

Schematics, waveforms, and a maintenance chart are included in this manual as service aids. Proper trouble shooting requires a vacuum tube voltmeter and a high quality oscilloscope.

In the event of failure, supply voltages should be checked first. If the ripple on the 300V bus bar exceeds a few tenths of a volt peak-to-peak, the 6AU6 control tube (V203) and/or the OA2 tube (V204) should be replaced. If there is no voltage on the 300V bus, the 5U4G rectifier tube (V201) and/or the 6080 series tube (V202) should be changed. If oscillations occur on the 300V bus, replace the 6080 tube or the OA2 tube. Absence of a bias supply may be caused by a failure of CR101 or CR102, the selenium rectifiers. If a short has occurred, R212 will be burned and should be replaced. If the power supply characteristics are correct, utilize the Maintenance Chart (Table 3) to locate and eliminate the source of trouble.

Read the chart from top down, the operation of one function depends on those directly above it or in line with arrows. The same reasoning applies to the grouped elements. OUTPUT CHANNEL A operation depends on the COUNTER function. Normally, the technician should start from the top of the chart, check the appropriate function, and work down.

If the unit counts properly, and gives a proper A output, the elements listed under COUNTER and OUTPUT CHANNEL A are functioning correctly and the trouble lies elsewhere. Following the order of the chart, test the gating operation of OUTPUT CHANNEL B, then the recycling operation.



MAINTENANCE GUIDE CHART  
TABLE 3

If no A output is present or several are, then the cause lies in the elements listed under OUTPUT CHANNEL A of the chart. Failure of the unit to count can be traced back to the DCU's, gate tube, or input circuit.

The following articles discuss servicing techniques. A comparison of the voltages with those given on the schematic diagrams may aid the diagnosis. Tubes are the most frequent cause of failure.

Counter Function First check the characteristics of the waveform applied to the instrument, then check the input to the units DCU position for pulses at pin 7. If pulses are not present, isolate the defective stage by tracing the circuit back to the point where pulses appear. Waveforms at pertinent points of the circuitry should be compared with those in Figure 8, particularly noting the amplitudes, rise times, and durations. If the correct drive is present at the first DCU, check the output of the remaining DCU's for correct scaling with an oscilloscope. If necessary, analyze the DCU circuitry (see Appendix A).

The unit may respond only to pulses of one polarity if the plates of V101 are unbalanced or cathode emission is low, especially with small input pulses. Unbalanced plates can be equalized by varying R104. If the instrument counts intermittently, one or more of the following factors is usually the cause: the plates of V101 are unbalanced, V101 is defective, or the input amplitude is low.

Whenever V101 is replaced, the phase inverter should be readjusted as described under "Routine Adjustments". When properly adjusted, a positive rise of eight volts minimum on either phase inverter plate is required to assure operation of the trigger circuit.

Output Channel A. The generation of more than one output after the "A" number is reached, indicates a faulty clamper binary or clamper tube. Set the unit counting slowly and preset a low number for this channel. When the "A" preset count is reached, the clamper binary, V113, should change state and stay in this state until reset. The plate voltage at pin 6 should rise from 80 V to 240 V. This rise should cause the clamper tube to conduct and clamp pin 10 of the DCU's below 50 V until reset.

Another possibility is that the SINGLE-DUAL switch is in DUAL without the OUTPUT A switch being in HOLD-RELAY. The symptoms are the same, since the clamper binary cannot be triggered under these conditions.

When no output is apparent in Channel A, and the OUTPUT A switch is in PULSE-RELAY or HOLD-RELAY, try the PULSE position. With an oscilloscope on pin 6, look for an output pulse which indicates a faulty relay drive tube, (V112A) and/or a defective relay. Also, examine the networks connected to the "relay" positions of S107. Make sure the output pulse width does not exceed the interval between reset pulses when the unit is recycling.

If no output is available from the multivibrator, V111, trace the circuitry back towards V109, noting whether any drive is applied to pin 1 of V111, to pin 1 of V110, and to pin 2 of the amplifier, V109.

If the grid of the amplifier (V109) does not rise to 0 volts at the preset count, the coincidence system is probably at fault. To locate the DCU with the faulty coincidence circuit, see the discussion under GATE function. The tubes of the A system are the first and third 5964's counting up from the DCU base; pin 10, the coincidence output pin.

Gate Function (Output Channel B). If all zeroes are preset in the B switches, the instrument will not count in the GATE position. Such a condition indicates that coincidence has been reached for a zero count and the input to the DCU's gated-off.

Erratic operation on the part of any individual coincidence circuit will disable the whole system. Failure generally occurs when the unit stops at the wrong count or doesn't stop at all. At the preset count, the voltage on pin 6 rises from 50 volts or less to 260 volts where it remains until the unit is reset. If this occurs, the coincidence system is in good order and the next step is to examine the amplifier, V104, and the succeeding stages and associated circuitry. When the preset count is reached, pin 7 of V103 should drop from 0 volts to about -60 volts.

To locate a DCU with a faulty coincidence circuit, separately disconnect the coincidence circuit of each DCU from the system by removing the two 5964 tubes until the remaining DCU's gives coincidence at the preset count. (The second and fourth tube from the base comprise the B coincidence circuit of each DCU) Start with the left hand DCU, the slowest counting one, and work towards the right. The last DCU disconnected is the one at fault.

Appendix A describes DCU servicing.

Where the unit stops at a number other than the preset count, it is quicker to examine each DCU which registers a digit other than the preset digit. Replace each DCU and test GATE operation.

DCU's with faulty preset circuits can also be found with the instrument in the RECYCLE position in the same manner. Remove DCU's from the circuit until the unit recycles properly. However, troubles in the reset circuitry and an extreme value of B+ invalidate this method.

The multivibrator V106 should always be driven through the lower diode, V105B, and through both diodes for a HOLD-RELAY output. In the latter case, the binary changes state and remains in the abnormal state until reset.

Occasionally, spurious triggering of the multivibrator tube caused by "chattering" of the RESET switch may occur when the pushbutton is depressed. To prevent this, the back pole of S106 is bent so that it makes last when the button is released. Such sequencing clamps the amplifier plate of V104 until the DCU's and the rest of the unit have stabilized. The multivibrator then cannot be driven during a manual reset operation.

Recycle Function. Primarily proper operation of the RECYCLE function depends on proper GATE operation, which means the generation of a coincidence output at the preset count. This output through the multivibrator furnished positive transients to reset the unit by means of the cathode-followers, V107B and V108A. If resetting is faulty, the cathode-followers are bad, the B+ value is extreme, or the output characteristics of V106 have changed.

To check the circuit, compare the waveforms for the multivibrator and cathode-follower with those in Figure 8, particularly noting the rise times, amplitudes, and durations. All waveforms were photographed with the instrument in the RECYCLE position and a 40Kc input. The oscilloscope sweep times are given for 10 centimeters. Note that the maximum recycling rate can be realized only if the PULSE WIDTH adjustment for both channels is set at the minimum value. Make sure the output pulse width does not exceed the period between reset pulses when the instrument is recycling.

If the reset circuit is in proper order, then the B+ value must be checked. For a given bias supply voltage, there is at least a 30 volt B+ range over which the instrument will recycle properly. The B+ range for the RECYCLE function limits the overall range of the instrument. At the upper limit, the instrument will not function for certain preset counts. At the lower limit, other counts cause failure, the sensitivity falls below the  $\pm 1$  volt value, or the relay may not energize completely.

With an input frequency of 20Kc or above, the OUTPUT switches in PULSE, and an oscilloscope tied to pin 3 of any DCU, the effect of different B+ values on the recycling operation for different pre-set counts can be observed. Set the B+ at +350 volts and observe the waveform periods for preset counts of 1 to 100. Lower the B+ value gradually if necessary until all counts recycle properly. This procedure gives the upper limit. Likewise, find the lower B+ limit by starting at 270 volts and going up. With this lower limit, the B+ range is known.

To check high-speed operation of Channel A:

1. Pull out V106, V104, and V112, the B multivibrator, B amplifier, and clamper tube, respectively.
2. Connect pin 6 of V111 to the 10 meg. side of C117.
3. Place function switch to GATE $\Omega$
4. Preset numbers from 1 to 100 in A switches and vary B+ as above for both limits.
5. Replace tubes and remove short when completed.

With the range of both channels known, set the B+ at a value within both ranges, centered between the two closest limits.

The above steps replaces the B channel with the corresponding portion of the A channel except for the relay drive tube, V112A, and this is not used in high-speed recycle operation.

# 5 Parts list

## NOTE

This list is compiled solely to help a repairman identify and replace defective components; consequently, parts which are adequately described on the schematic diagrams are not listed here. Parts listed appear in all Dual Preset Counters (Models 5442 thru 5446) unless otherwise noted.

## DECIMAL COUNTING UNITS

Model 5442 contains two Model 732 DCU's

Model 5443 contains three Model 732 DCU's

Model 5444 contains four Model 732 DCU's

Model 5445 contains five Model 732 DCU's

Model 5446 contains six Model 732 DCU's

(No component parts of Decimal Counting Units are listed below)

## TUBES

| <u>Type</u> | <u>Quantity</u> | <u>Type</u> | <u>Quantity</u> |
|-------------|-----------------|-------------|-----------------|
| 12AT7       | 1               | 5U4G        | 1               |
| 5963        | 9               | 6080        | 1               |
| 6AS6        | 1               | 6AU6        | 1               |
| 6AL5        | 2               | OA2         | 1               |

## OTHER COMPONENTS

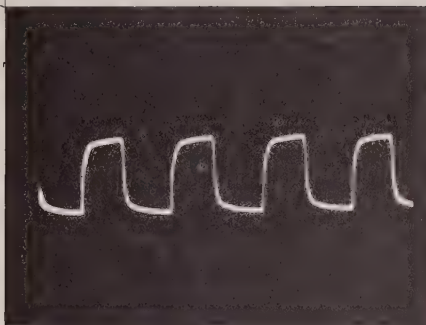
| <u>Detail No.</u> | <u>Stock No.</u> | <u>Description</u>                          | <u>Mfr. &amp; No.</u> |
|-------------------|------------------|---------------------------------------------|-----------------------|
| B101              | 9-3390           | Fan Motor, 4" Fan                           | Gen. Industries A-5-  |
| C114              | 2-0763           | Capacitor, .1 $\mu$ fd, 400 V, Molded Paper | Sangamo Type 30 300   |
| C126              |                  | Same as C114                                |                       |
| C201 &<br>C202    | 2-0703           | Capacitor, 10 $\mu$ fd, 600 V               | Sangamo CP70B1FF10    |
| C204              | 2-1001           | Capacitor, 20 $\mu$ fd 450 V                | Sangamo MT 4520       |
| C205 &<br>C206    | 2-2499           | Capacitor 30 $\mu$ fd, 450 V                | Sangamo PL 4530       |
| C207              |                  | Same as C203                                |                       |

# OTHER COMPONENTS (Continued)

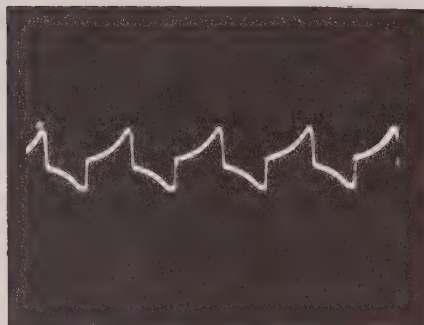
| Detail No.       | Stock No. | Description                            | Mfg. Co. No.                     |
|------------------|-----------|----------------------------------------|----------------------------------|
| CR101 &<br>CR102 | 8-1699A   | Rectifier 6M1                          | Radio Receptor Co.               |
| F201 &<br>F202   | 7-2213    | Fuse 3A-125 V, 3 AG                    | Littlefuse 31300.2               |
| I201 &<br>I202   | 21-1677   | Pilot Lamp                             | GE #47                           |
| J202             | 17-1665   | Connector                              | AN 3102A-18-1S                   |
| J203             | 17-3735   | Connector                              | AN 3102A-22-19P                  |
| K101 &<br>K102   | 16-5756   | Relay As per Spec. Dwg.                | Berkeley                         |
| L201             | 3-6203    | Choke                                  | Osborne #5701                    |
| R101             | 1-2316    | Potentiometer, 1 M, 2 W, 20 %          | AB CU 1052                       |
| R104             | 1-2329    | " 500 $\Omega$ , 2 W, 10 %             | AB CLU 5011                      |
| R129             | 1-5653    | Potentiometer 5 M, 2 W, 20 %, Linear   | AB JU 5052                       |
| R160             |           | Same as R129                           |                                  |
| R201             | 1-0979    | Resistor, 150 $\Omega$ , 10 W, WW      | Ohmite                           |
| R210             | 1-0644    | Potentiometer 250 K, 2 W, Linear Taper | AB JU 2541                       |
| R214             | 1-3545    | Resistor, 1500 $\Omega$ , 10 W, WW     |                                  |
| S101             | 12-1641   | Switch, SPDT                           | C- H 8282K13                     |
| S102 &<br>S103   | 12-3450   | Switch, 4 Pole- 6 Pos.,                | Centralab PA 2011                |
| S104             | 12-1643   | Switch, SPST                           | C - H 8280K15                    |
| S105             |           | Same as S101                           |                                  |
| S106             | 12-3188   | Switch 3PDT                            | Switchcraft 1009                 |
| S107             |           | Same as S102                           |                                  |
| S201             | 12-1642   | Switch, Toggle DPST                    | C - H 8270K8                     |
| S202             | 12-3851   | Switch, DPST                           | C - H 8370K7                     |
| S203             | 12-3452   | Thermoswitch 6 -125 Volts AC           | Miniature Thomas Edison Type 210 |
| T201             | 6-3448    | Transformer As Per spec. dwg.          | Electro Eng. E8377               |

Tube List

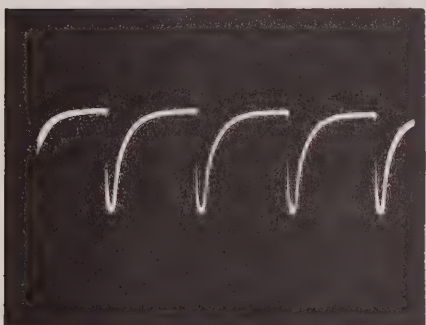
| <u>Tube</u> | <u>No Required Per Unit</u>                              |
|-------------|----------------------------------------------------------|
| 5U4G        | 1 (V201)                                                 |
| 6AU6        | 1 (V203)                                                 |
| 6080        | 1 (V202)                                                 |
| OA2         | 1 V204)                                                  |
| 6AS6        | 1 V103)                                                  |
| 12AT7       | 1 V101)                                                  |
| 5963        | 9 (V102, V104, V106, V107, V108, V109, V111, V112, V113) |
| 6AL5        | 2 (V105, V110)                                           |



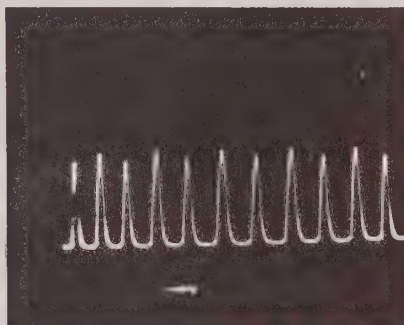
A. Schmitt Trigger output at pin 6 of V102. peak to peak amplitude 75 volts, rise time 1.5  $\mu$ sec, and oscilloscope sweep time 100  $\mu$ secs.



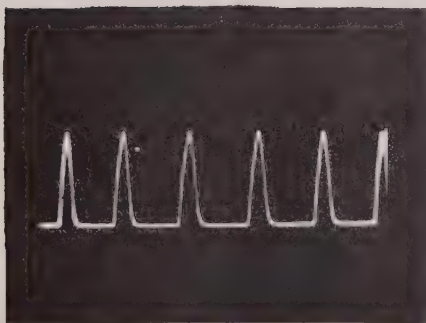
B. Gate tube input at pin 1 of V103. Positive peaks are slightly clipped when the tube draws grid current. Peak-to-peak amplitude 75 volts oscilloscope sweep time 100  $\mu$ secs.



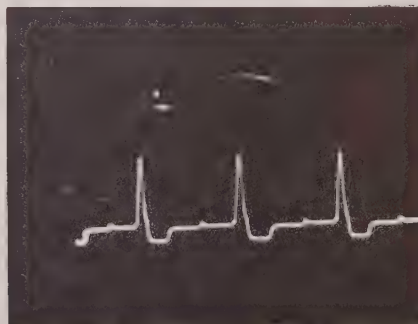
C. Gate tube output at pin 5 of V103. The amplitude of the amplitude of the negative pulses is 120 volts and the oscilloscope sweep time 100  $\mu$ secs.



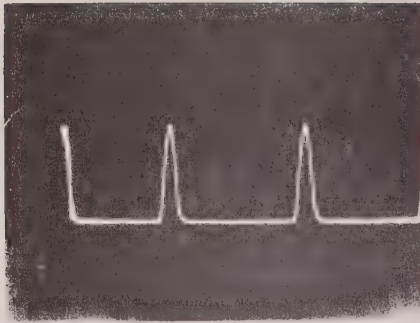
D. Coincidence system output at pin 6 of any Model 732 DCU for a preset count of 1 (1 in the "B" switch of units bank, AY101, with all other switches at 0). With unit in RECYCLE, the frequency of this train of pulses is 40 kc, which is equal to the input frequency. Correspondingly, the period is 25  $\mu$ secs. When recycling, the amplitude of the coincidence pulses is about 120 volts. Oscilloscope time, 250  $\mu$ secs.



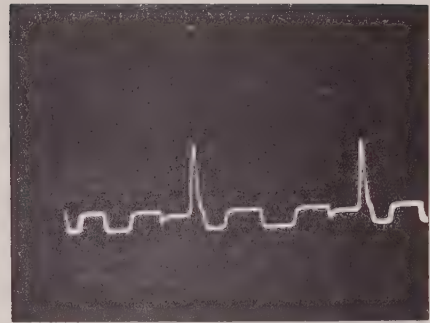
E. Coincidence system output at pin 6 of any DCU for a preset count of 2 in "B" channel. Amplitude of 120 volts and period of the waveform 50  $\mu$ secs, twice that of input waves. Oscilloscope sweep time, 250  $\mu$ secs.



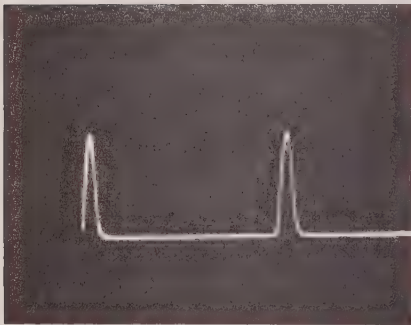
F. Coincidence system output at pin 6 of any DCU for a preset count of 3 in "B" channel. Amplitude, 120 volts and period, 75  $\mu$ secs, three times that of input waves. Oscilloscope sweep time, 250  $\mu$ secs.



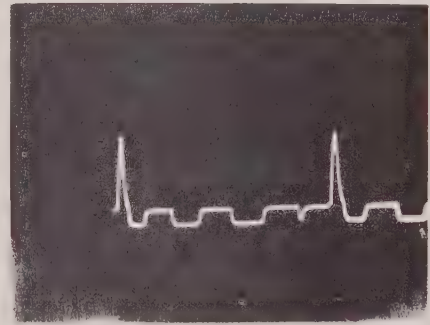
G. Coincidence system output at pin 4 of any DCU for a preset count of 4 in "B" channel. Amplitude 120 volts, period is 100  $\mu$ secs, four times that of input waves. Oscilloscope sweep time 2.5  $\mu$ secs.



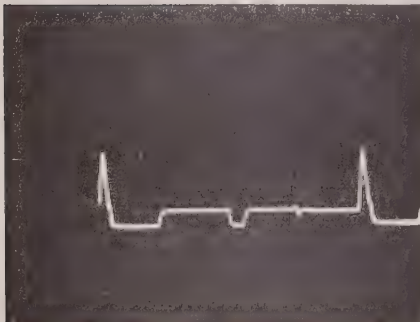
H. Coincidence system output at pin 6 of any DCU for a preset count of 5 in "B" channel. Amplitude, 120 volts, period 125  $\mu$ secs, five times that of input waves. Oscilloscope sweep time 250  $\mu$ secs.



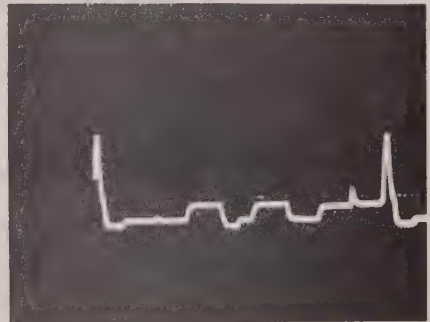
I. Coincidence system output at pin 8 of any DCU for a preset count of 6 in "B" channel. Amplitude, 120 volts, period 150  $\mu$ secs, six times that of input waves. Oscilloscope sweep time 250  $\mu$ secs.



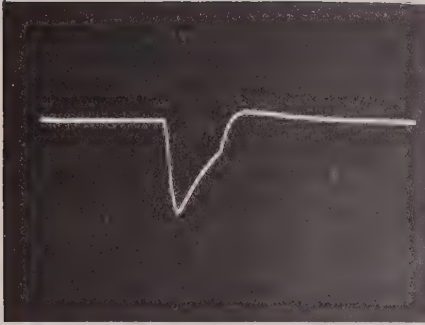
J. Coincidence system output at pin 3 of any DCU for a preset count of 7 in "B" channel. Amplitude, 120 volts, period is 175  $\mu$ secs, seven times that of input waves. Oscilloscope sweep time 250  $\mu$ secs.



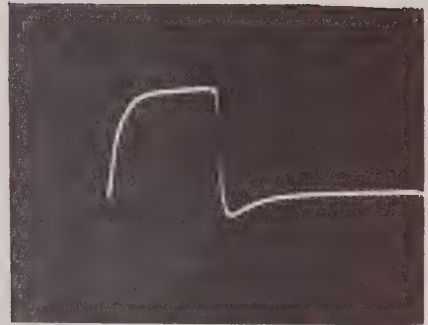
K. Coincidence system output at pin 5 of any DCU for a preset count of 8 in "B" channel. Amplitude, 120 volts, period of 200  $\mu$ secs, eight times that of input waves. Oscilloscope sweep time 250  $\mu$ secs.



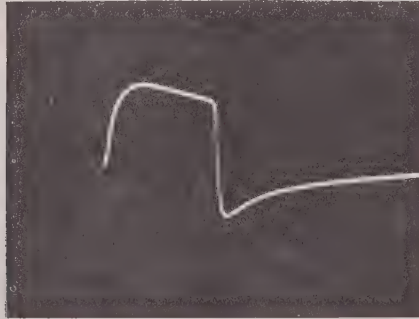
L. Coincidence system output at pin 6 of any DCU for a preset count of 9 in "B" channel. Amplitude, 120 volts, period 225  $\mu$ secs, nine times that of input waves. Oscilloscope sweep time 250  $\mu$ secs.



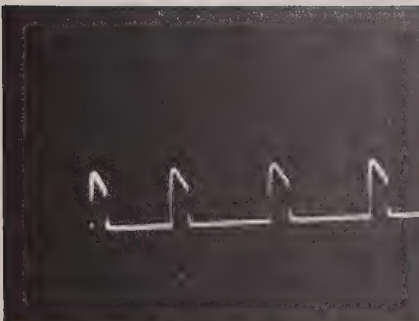
M. Inverter amplifier output at pin 1 of V104. Voltage level drops from 275 to 150 volts at coincidence. 20  $\mu$ secs later, the original voltage level is restored. Oscilloscope sweep time, 100  $\mu$ secs. Waveform at pin 1 of V109, generated when "A" coincidence is reached, is identical to this.



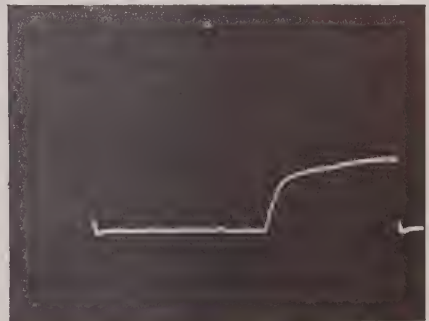
N. One-shot multivibrator output at pin 6 of V106. Rise time, 3  $\mu$ secs, duration of 12  $\mu$ secs (for minimum PULSE WIDTH ADJ. and OUTPUT B switch at PULSE) and an amplitude of 125 volts. Oscilloscope sweep time, 50  $\mu$ secs. With the relay in the circuit, the duration is 0.02 seconds. Waveform at pin 6 of V111 for "A" coincidence is identical to this when OUTPUT A switch is at PULSE. Waveform at pins G and H of accessory socket is similar except that amplitude is 45 volts.



O. Cathode-follower input at pin 2 of V107 when OUTPUT B switch is at PULSE. Oscilloscope sweep time, 50  $\mu$ secs, amplitude, 120 volts.



P. Cathode-follower output at pin 8 of V107 for preset count of 3 in "B" channel and unit in RECYCLE. Amplitude 65 volts, rise time of 3  $\mu$ secs and a duration of 12  $\mu$ secs. Oscilloscope sweep time, 250  $\mu$ secs.



Q. DCU output, pin 4 of AY101, the units bank. Amplitude 80 volts. Oscilloscope sweep time, 250  $\mu$ secs.

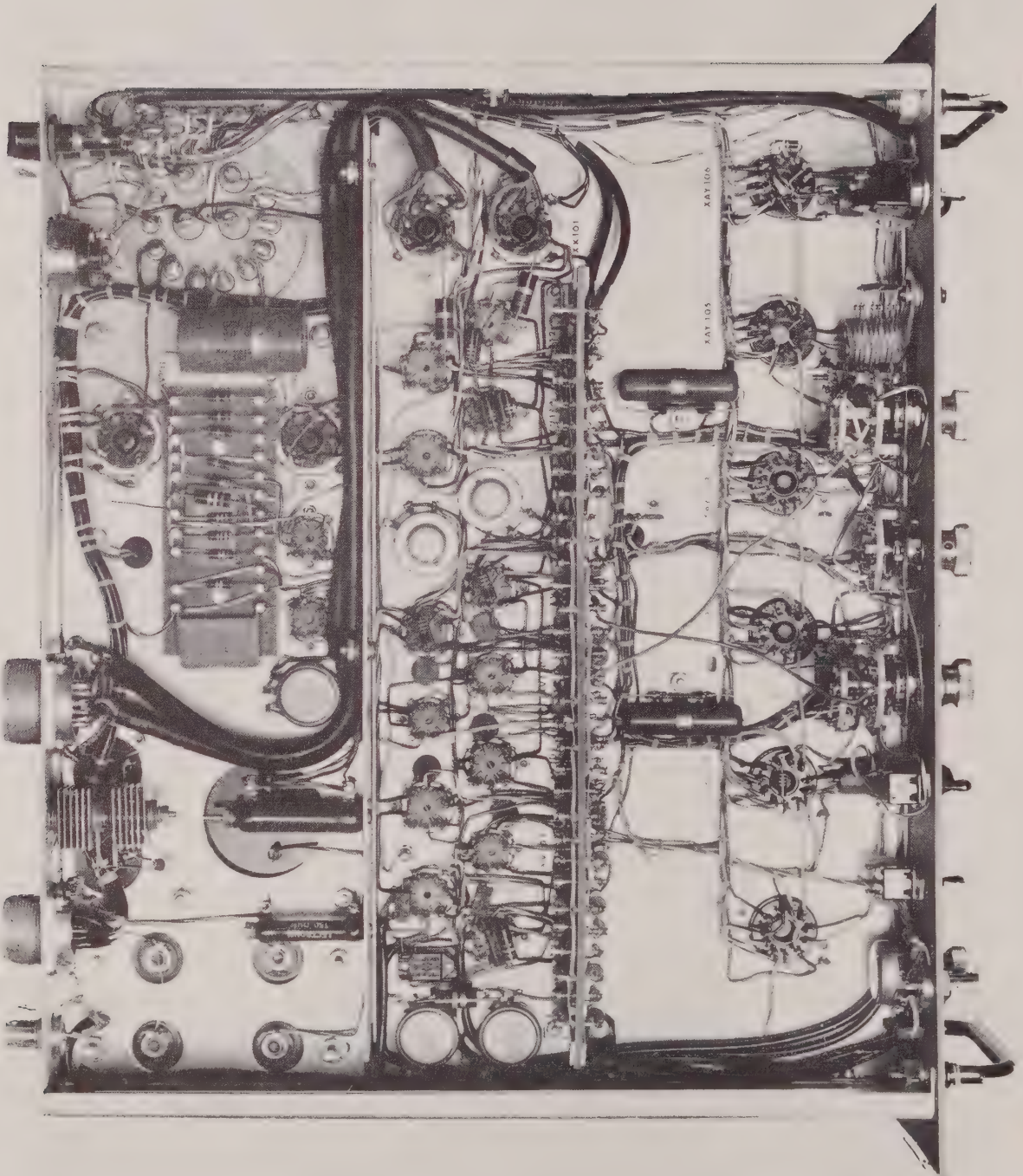
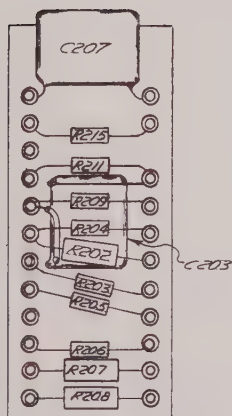
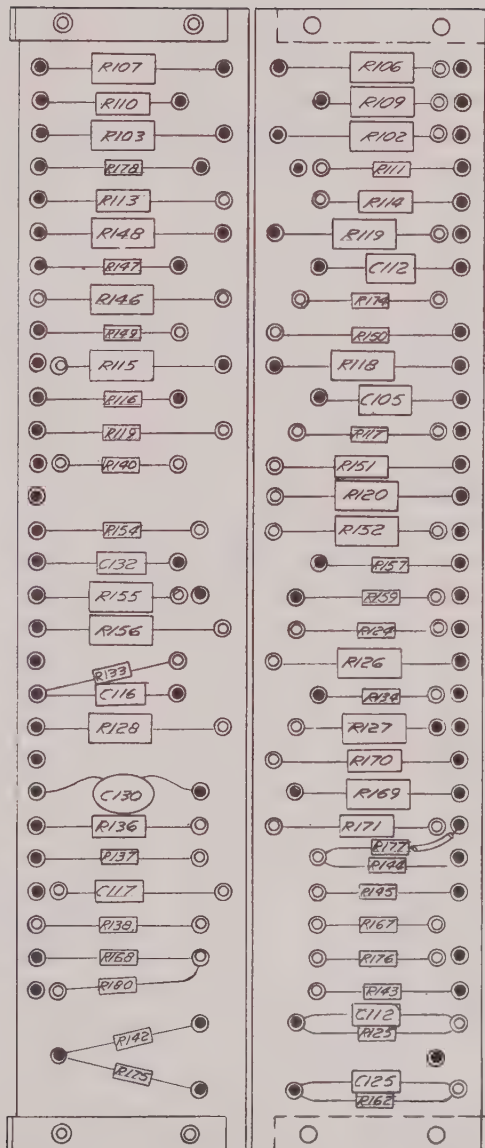


Figure 9 Parts Layout, Chassis



TERMINAL BOARD NO. 1



TERMINAL BOARD NO. 2A      TERMINAL BOARD NO. 2B

Figure 10 Parts Layout, Terminal Boards











INSTRUCTION  
MANUAL

STANDARD TECHNICAL  
TECHNICAL FILE - 100-100000-10  
*Chris Warren*  
DOCUMENT CONTROL ADMINISTRATOR

APPENDIX A

BERKELEY  
PRESET DECIMAL COUNTING UNIT

Model 732

BERKELEY division of  
Beckman Instruments, Inc.

Richmond 4, California  
15 March 1954

## WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

- (a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.
- (b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.
- (c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.
- (d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.
- (e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.
- (f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.
- (g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

## REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION  
BECKMAN INSTRUMENTS, INC.

## SPECIFICATIONS

|                                    |                                                                                  |
|------------------------------------|----------------------------------------------------------------------------------|
| Count Indication                   | Direct reading decimal presentation.                                             |
| Power Requirements                 | Heater: 6.3 v. at 3A amps.<br>Plates: 300 v. at 18 ma.<br>Bias: -150 v. at 1 ma. |
| Input Requirements,<br>recommended | Negative pulse 90 volts peak amplitude.                                          |
| Rise Time                          | 1 $\mu$ second.                                                                  |
| Duration                           | At least 2 $\mu$ seconds.                                                        |
| Counter Output Characteristics     | Designed to drive another Model 732.                                             |
| Coincidence Amplifier<br>Output    | 200 volt positive transient.                                                     |
| Reset                              | Manual or electronic (see Section 3,<br>Operation).                              |
| Resolution of Paired<br>Pulses     | 5 $\mu$ seconds.                                                                 |
| Maximum Counting<br>Rate           | 40,000 cps for single unit.                                                      |
| Construction                       | Plug-in unit for 11-pin socket.                                                  |
| Dimensions                         | 2-1/2 "x 5-1/2" x 6-1/2"                                                         |
| Weight                             | 1 lb. 7 oz.                                                                      |
| Tubes                              | 4 ea. 5963; 2 ea. 5964.                                                          |



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## Section 1 INTRODUCTION

The Berkeley Dual Preset Decimal Counting Unit, Model 732, is a high speed electronic counter combined with two coincidence amplifiers designed to emit an output from each coincidence amplifier for any count between one and ten. Each count is selected by presetting a rotary switch on the front panel. When both switches are set at "0", the unit functions as a conventional decimal counter, counting from zero to nine, the tenth pulse resetting the unit to zero and simultaneously generating an output signal. When a number other than "0" is preselected, the coincidence amplifiers generate an output signal at that count. By making use of the coincidence amplifier output from the second or larger number to reset the unit (see Section 3), the Model 732 can be used as a counter with a variable scaling factor of any number from one to nine. This method of reset may also be used when the unit counts or measures quantities such as numbers of objects or periods of time. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel.

Any number of these units can be connected in cascade (the output of one unit driving the next), forming a preset counter whose total count capacity will be dependent only on the number of Model 732 units. Thus, five units will count and reset for any number from one to 100,000.

The maximum counting rate is 40,000 cycles per second with a resolution time of 5 microseconds.

## Section 2 THEORY OF OPERATION

### Counter Circuit Analysis

The basic circuit of the counter section of the Model 732 is a modification of the Eccles-Jordan trigger circuit with two stable states, known as a binary. The binary is a two-stage amplifier with the output of the second stage connected to the input of the first, as shown in Figure 1.

With no input, the loop gain is less than one, and the circuit is in one of its two stable states, i.e., either V2 conducting and V1 cut off, or vice-versa. The circuit is triggered from one state to the other by making the loop gain greater than one. The binary is coupled to a single trigger source through C1 and R1 in such a way that the effect of the trigger is different on the two stages, depending on which stage is conducting. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through the cross-over network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. When the input pulse is of sufficient amplitude, the loop gain becomes greater than one, and the binary is triggered to its other stable state, V1 conducting and V2 cut off. The next input pulse reverses the process and causes the binary to return to its original state. Thus, the binary completes a cycle for every two input triggers and is a scale of two. By a cascade arrangement of binaries, a counter having a scale of any power of two can be obtained.

In the Model 732, four binaries are connected in cascade, forming a scale of sixteen which is permuted to a scale of ten by two resistor-capacitor "feedback" networks (see Figure 2).

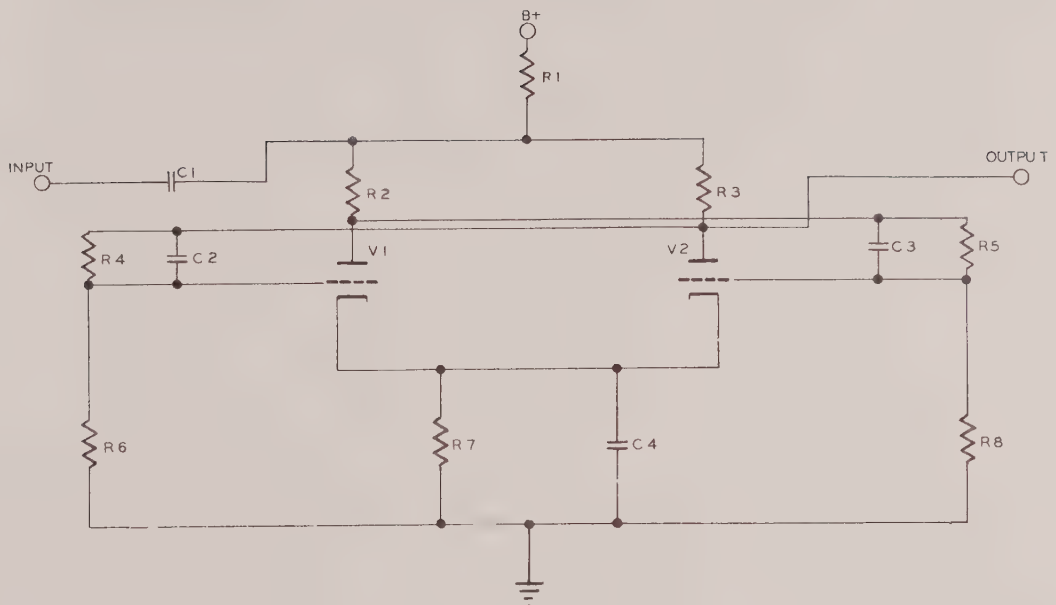


**Figure 2 Basic Circuit**

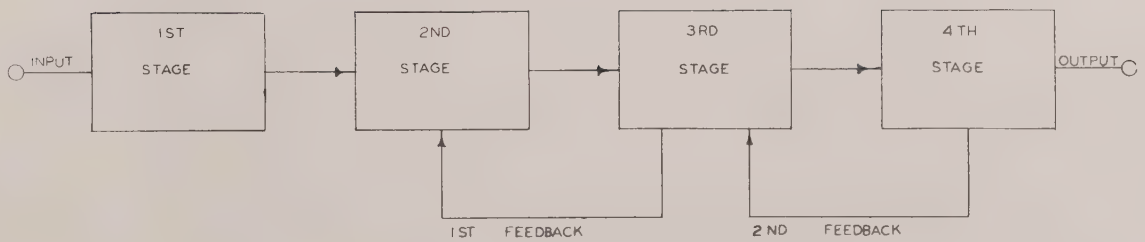


**Figure 3 Functional Diagram**

The circuit operates as a conventional binary counter up to the count of four. On the count of four the third stage is triggered, sending a pulse through the first feedback network, thereby triggering the second stage. Since it requires two inputs to trigger the second stage, this is the equivalent of adding two input pulses and the unit now corresponds to a binary count of six. On the count of six (which is the equivalent of eight in a binary counter) the fourth stage is triggered, sending a pulse through the second "feedback" network and triggering the third stage, which is operationally equivalent to injecting four input pulses to a unit storing a binary count of twelve. The unit again operates as a binary scaler for the remaining four pulses required to reset it to zero. Therefore, by adding the equivalent of six input pulses, the scale of sixteen has been permuted to a scale of ten.

### Coincidence Circuit Analysis

Two identical coincidence amplifiers are used in the Model 732. Each consists of four triodes (type 5964), twelve resistors, and a 4-pole, 10-position rotary switch. The discussion that follows is applicable to either or both amplifiers.

Four resistor-dividers are connected between four of the plates of the counting unit and -150 volts. The divider ratio is such that if the resistor connected to the -150 volts is shorted, its tube will be cut off at all times. However, if this short is removed, the divider ratio is such that the tube follows the plate of the binary to which it is connected, i. e., if the short around R157 is opened, V105 will be turned on and off, depending on the state of the first binary, B101. Since the plates as well as the cathodes of V105 and V106 are connected together, coincidence is obtained when all four tubes are at plate current cut-off.

The number to be preset is selected by pushing one of ten buttons on a switch. The #4 button opens switch S104, the #5 button opens switch S105, etc.

When any number other than zero is selected and the unit is reset to zero, at least one coincidence triode will be conducting. As the count progresses, the number of tubes conducting varies in such a way that when the preset number is reached, all the triodes are cut off and a

large positive transient is obtained at the output of the coincidence amplifier. This information is used either to reset the unit to zero through a cathode follower reset circuit, or to gate off the input pulses.

When a constant input frequency is put into the instrument, it can be used as a variable frequency divider or a variable time delay.

## Section 3 OPERATION

### Installation

Normally, the Model 732 DCU is installed as a plug-in unit in a Berkeley instrument. No special instructions are necessary. For information concerning unusual installations, we invite your inquiry.

### Operation

#### Power requirements:

Plates ----- 300 volts at 19 ma.  
Filaments ---- 6.3 volts at 3.0 amps.  
Bias ----- 150 volts at 1 ma.

#### Input requirements:

Counter circuit -- When the unit is powered by an unregulated supply, the drive amplitude should vary with the supply voltage. A negative transient is required to drive the unit. It can be either a square wave, or a rectangular pulse which is at least 2  $\mu$ secs. wide. The pulse amplitude in either case is dependent upon the rise time. For a rise time of 0.5  $\mu$ sec. (measured between the 10% and 90% values), the pulse amplitude should be between 75 and 135 volts, while for a rise time of 2  $\mu$ secs., the amplitude should be between 120 and 165 volts. The recommended values are 1  $\mu$ sec. rise time and 100 volts amplitude for a 300 volt supply.

DCU input load -- The load at triggering is equivalent to 100  $\mu$ f in series with 15K.

Reset circuitry -- By using the circuit shown in Figure 5, the unit can be electronically or manually reset. Other circuits may also be used, provided a positive pulse of the correct amplitude, width and rise time is applied to the reset pin (Pin #3 of the 11-pin plug) of the Model 732. The required pulse amplitude is dependent upon

its rise time and the number of units being reset. The recommended values for one unit are: 3  $\mu$ secs. rise time, 15  $\mu$ secs. pulse width, and 70 volts amplitude.

If electronic reset is not required, the reset pin should be connected to ground through a normally-closed switch or relay contacts. To reset the unit, the contacts are opened momentarily. Care must be taken to avoid coupling the voltage surges into the input or power supply circuits.

#### Output requirements:

Counter circuit -- The output is a rectangular waveform presented at the output terminal as a change in d-c voltage (see fourth stage, Figure 3). On the counts from "0" to "5", its value is 55 volts. For the counts "6" and "7", it is 127 volts, while for "8" and "9" it is 135 volts. The step between "7" and "8" is due to the effect of the interpolation network. The load imposed on the unit must not be more than 300,000 ohms to ground, or a 6,000 ohm resistor in series with 100  $\mu$ f.

Coincidence amplifier circuit -- A plate load resistor for each coincidence amplifier must be connected between pins 5 and 10, and pins 5 and 6 of the 11-pin plug. These resistors should be large (about 47K) compared to the plate resistance of any one of the tubes when it is conducting. When several units are connected in cascade, pin 10 of each unit should be directly connected to pin 10 of every other unit; pin 6, directly connected to pin 6 of every other unit. Output waveforms (pin 10) are shown for each position of the preset switch in Figure 4.

## Section 4 MAINTENANCE

### General

When a Preset Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. The counting unit is usually the indicating device of an instrument, and is quite often accused of counting incorrectly when the fault is external to it.

### NOTICE

Before attempting to trouble-shoot

this counter circuit, V105 and V106

should be removed from their sockets.

### Counter Circuit Troubleshooting

Two methods are recommended for finding the trouble in a faulty counting circuit: first, observe the lighting sequence while driving the unit at a slow repetition rate; and second, observe the waveform of each stage on an oscilloscope at a rate high enough for convenient viewing. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Table 1 lists common troubles and their causes. When a stage is indicated to be at fault, the trouble usually is the tube. Faulty tubes are the most frequent source of delinquency in any stage.

Table 1  
COMMON TROUBLES\*

| <u>Symptom</u>                                                                                                                                                                                                                           | <u>Cause</u>                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unit Fails to Count                                                                                                                                                                                                                      | (a) Insufficient supply voltage.<br>(b) Input signal of insufficient amplitude.<br>(c) Input signal of wrong polarity<br>(d) First stage inoperative. |
| Unit Counts Spuriously                                                                                                                                                                                                                   | (a) Stray output signal.<br>(b) Pulses received through power supply.<br>(c) External voltages picked up by output lead.                              |
| Unit Counts Erratically                                                                                                                                                                                                                  | (a) Input signal too large or small, incorrect rise time.<br>(b) Supply voltage fluctuating too much.                                                 |
| Unit Fails to Reset                                                                                                                                                                                                                      | (a) Stray counts from reset switch or associated circuitry.<br>(b) Defective component                                                                |
| Unit Counts in Wrong Sequence (the pattern of lighting is repeated after a definite number of input pulses. One or more lights may be "On" simultaneously during a cycle provided that the number of states per cycle remains constant). |                                                                                                                                                       |
| 1. Unit skips every other number.                                                                                                                                                                                                        | (a) First stage defective.<br>(b) Input circuit supplies double pulses.                                                                               |
| 2. Two stable states per cycle.                                                                                                                                                                                                          | (a) Second stage defective (count can be 01 or 45).<br>(b) Loss of drive to second stage (01).                                                        |
| 3. Four stable states per cycle.                                                                                                                                                                                                         | (a) Third stage defective (count can be 0123 or 6789).<br>(b) Loss of drive to third stage (0123).                                                    |

4. Six stable states per cycle.

- (a) Output excessively loaded  
(count can be 012345-012345).
- (b) Last stage inoperative (count  
can be  
01234501 etc. or 67<sup>89</sup><sub>8</sub>89. The  
count 2 indicates both "8" and  
"2" lamps are on.
- (c) Loss of drive to fourth stage  
(count can be 012345).

5. Eight stable states per cycle  
or any failure where two succes-  
sive numbers are skipped.

- (a) Second or third stage failure.

6. Ten stable states per cycle,  
but the lighting sequence is  
incorrect.

- (a) Where the "0" neon lamp lights  
instead of the "4", the trouble  
is with either the "0" or "4"  
lamp, and in the majority of  
cases it is "4". This can happen  
on any count; zero and four were  
used as examples. It is also pos-  
sible that more than one lamp may  
light in place of or with the one  
that fails.

7. Twelve stable states per cycle.

- (a) When lighting sequence is  
01  
012345456789-0, etc. (the count 4  
indicates both "0" and "4" lamps  
are on.)  
First feedback failure.  
Second or third stage losing  
emission.
- (b) When the lighting sequence is  
23  
012345678989-0, etc.  
Second feedback failure.  
Third or fourth stage losing  
emission.

\*Reset Unit before troubleshooting.

## Troubleshooting the Coincidence Amplifier and Preset Switch

If one of the coincidence amplifier tubes fails, the preset output may not occur on the count corresponding to the pushbutton depressed. The following table shows the count on which the coincidence output is obtained when one of the two tubes is out of the socket:

| <u>Number Preset</u> | <u>Count on which coincidence is obtained when</u> |                                        |
|----------------------|----------------------------------------------------|----------------------------------------|
|                      | <u>V105 or V105-1</u><br><u>is out</u>             | <u>V106 or V106-1</u><br><u>is out</u> |
| 0                    | No output                                          | No output                              |
| 1                    | No output                                          | 1                                      |
| 2                    | No output                                          | 2                                      |
| 3                    | No output                                          | 3                                      |
| 4                    | 4                                                  | No output                              |
| 5                    | 4                                                  | 1                                      |
| 6                    | 6                                                  | No output                              |
| 7                    | 6                                                  | 1                                      |
| 8                    | 6                                                  | 2                                      |
| 9                    | 6                                                  | 3                                      |

Any failure that is not remedied by replacing V105 and V106 with good tubes is probably due to malfunction of the switch stacks. Make sure that there is no dirt in the contacts and that they are normally closed, opening only when a button is depressed.

## Diagrams and Tables

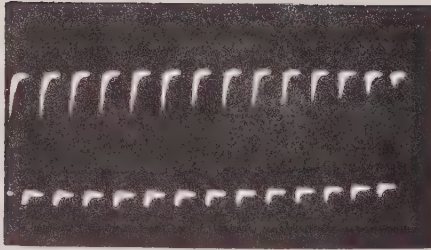
Figure 3 shows the typical waveforms of each stage when the counting circuit is working properly. A study of these and the corresponding ones on a faulty unit will help in locating component and tube failures. The spikes at the count of "4" on the second stage and at "6" on the third stage are caused by the first and second feedbacks, respectively. Figure 4 shows the output waveforms of the coincidence amplifier with a 47K resistor between pins 5 and 10 or 5 and 6. Circuit drawings and parts location diagrams will be found at the rear of the manual. The voltages shown

were obtained with a vacuum tube voltmeter, a supply voltage of 300 volts, and measured between ground and the point indicated. The unit must be reset to zero to obtain the values shown.

Table 2 lists the voltages and resistances between the tube socket connections and ground so that, in conjunction with the schematic and parts location diagrams, all information necessary to maintain the equipment in proper working order is available. It should be remembered that the values given are nominal, and considerable variation may be encountered owing to various line voltage conditions and component tolerances. All voltages were measured with a VTVM with the units at "0" (reset) position and "0" set on each switch. All resistances were measured with the unit out of the socket and pins 3 and 8 of the 11-pinplug shorted together, and a 47K resistor between pins 5 and 10 or 5 and 6.

Table 2  
MODEL 732-VOLTAGES & RESISTANCES

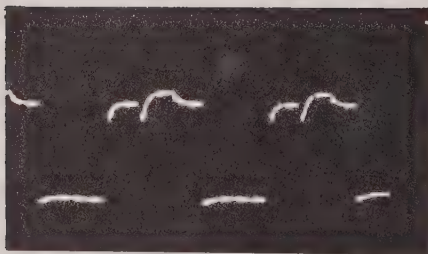
| <u>Tube</u>        | <u>Pin. No.</u> | <u>D.C. Voltage<br/>to ground</u> | <u>Resistance to<br/>Ground (in Ohms)</u> |
|--------------------|-----------------|-----------------------------------|-------------------------------------------|
| V101               | 1               | 170                               | 105K                                      |
|                    | 2               | 17                                | 85K                                       |
|                    | 3, 8            | 37                                | 12K                                       |
|                    | 4, 5, 9         | Filaments                         |                                           |
|                    | 6               | 60                                | 105K                                      |
|                    | 7               | 37                                | 85K                                       |
|                    |                 |                                   |                                           |
| V102               | 1               | 135                               | 93K                                       |
|                    | 2               | 15                                | 83K                                       |
|                    | 3, 8            | 30                                | 12K                                       |
|                    | 4, 5, 9         | Filaments                         |                                           |
|                    | 6               | 55                                | 93K                                       |
|                    | 7               | 30                                | 83K                                       |
|                    |                 |                                   |                                           |
| V103               | 1               | 135                               | 100K                                      |
|                    | 2               | 15                                | 83K                                       |
|                    | 3, 8            | 30                                | 12K                                       |
|                    | 4, 5, 9         | Filaments                         |                                           |
|                    | 6               | 55                                | 100K                                      |
|                    | 7               | 30                                | 83K                                       |
|                    |                 |                                   |                                           |
| V104               | 1               | 135                               | 93K                                       |
|                    | 2               | 15                                | 83K                                       |
|                    | 3, 8            | 30                                | 12K                                       |
|                    | 4, 5, 9         | Filaments                         |                                           |
|                    | 6               | 55                                | 93K                                       |
|                    | 7               | 30                                | 83K                                       |
|                    |                 |                                   |                                           |
| V105 and<br>V105-1 | 1, 2            | 300                               | 140K                                      |
|                    | 3, 4            | Filaments                         |                                           |
|                    | 5               | -25                               | 500K                                      |
|                    | 6               | -20                               | 500K                                      |
|                    | 7               | 0                                 | 0                                         |
|                    |                 |                                   |                                           |
| V106 and<br>V106-1 | 1, 2            | 300                               | 140K                                      |
|                    | 3, 4            | Filaments                         |                                           |
|                    | 4, 6            | -25                               | 500K                                      |
|                    | 7               | 0                                 | 0                                         |
|                    |                 |                                   |                                           |



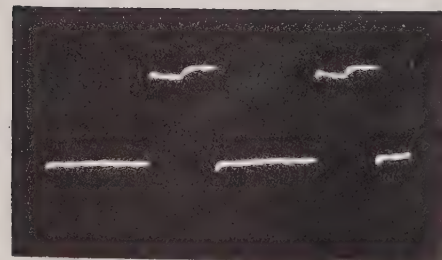
A. First Stage, Pin 6, V101, UVL + 168,  
LVL + 58, frequency 20Kc.



B. Second Stage, Pin 6, V102, UVL + 140,  
LVL + 55, frequency 20 Kc.

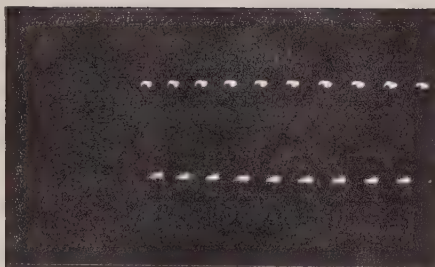


C. Third Stage, Pin 6, V103, UVL + 140,  
LVL + 55, frequency 20 Kc.

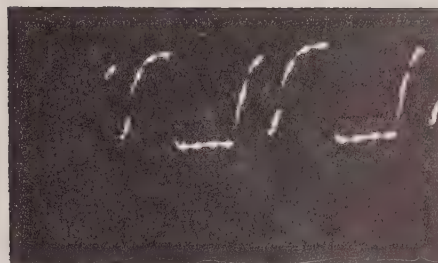


D. Fourth Stage, Pin 6, V104, UVL + 140,  
LVL + 55, frequency 20Kc.

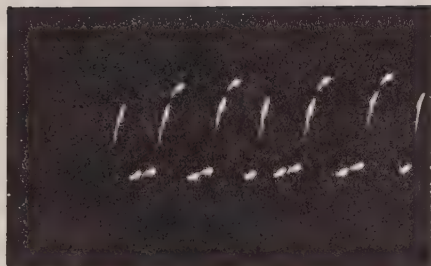
**Figure 3 Typical Waveshapes Model 732A**



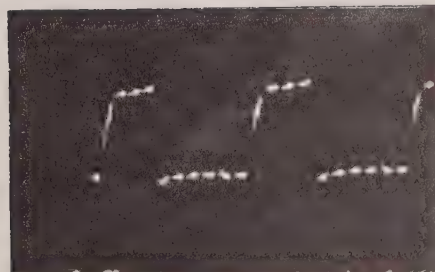
E. First Stage, Pin 6, V101, UVL + 168,  
LVL + 58, frequency 100Kc.



F. Second Stage, Pin 6, V102, UVL 140,  
LVL + 55, frequency 100Kc.

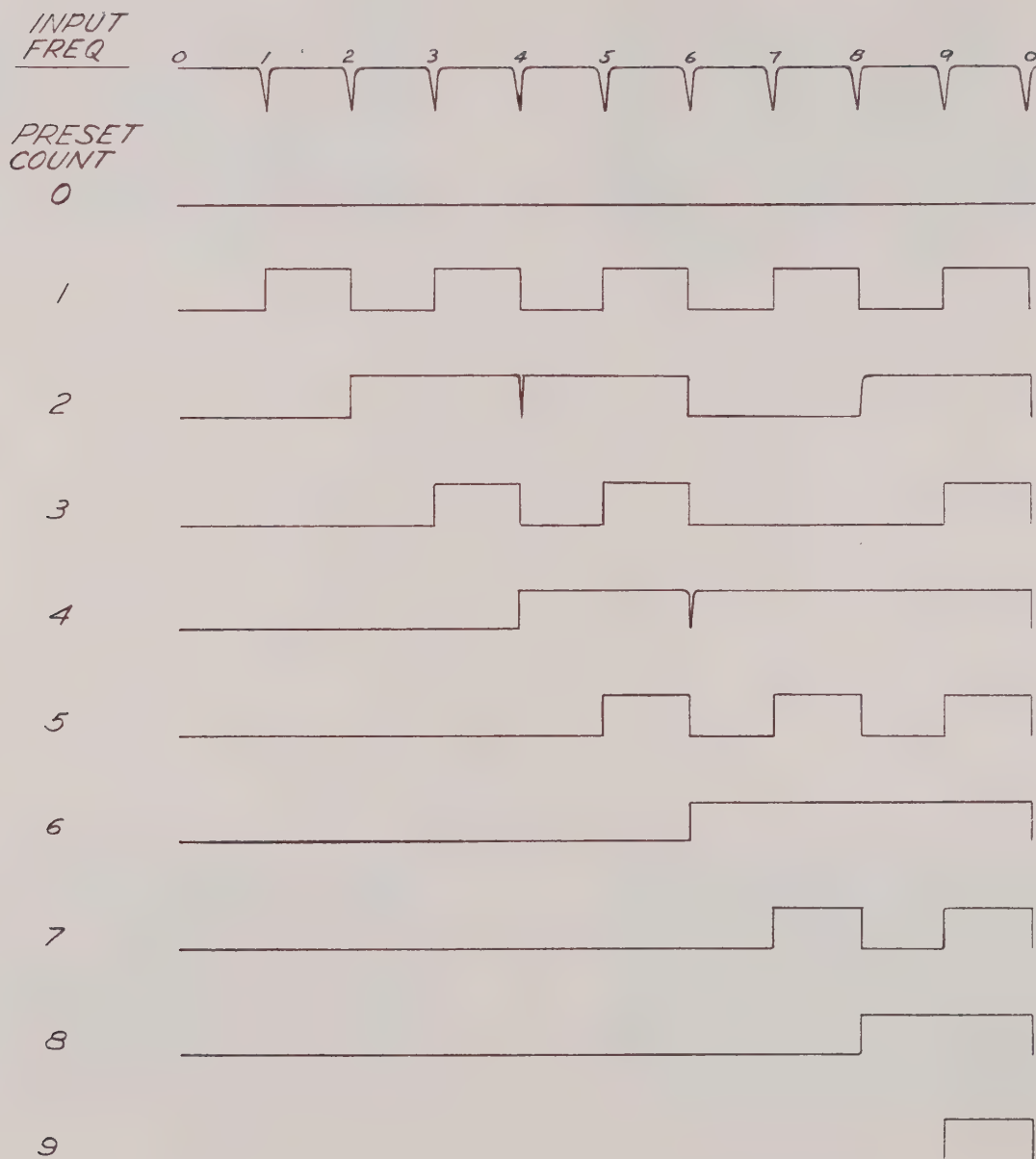


G. Third Stage, Pin 6, V103, UVL + 140,  
LVL + 55, frequency 100Kc.



H. Fourth Stage, Pin 6, V104, UVL + 140,  
LVL + 55, frequency 100 Kc.

Note: UVL = upper voltage level  
LVL = lower voltage level  
All waveforms are blanked



Note:

To obtain the above waveforms, do not couple the preset output to the reset pin.

Figure 4 Coincidence Amplifier, Plate Waveforms





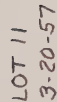


**Figure 6 Schematic Diagram, Model 732 Decimal Counting Unit**

NOTE: PRESET "B" IDENTICAL TO PRESET "A" AS SHOWN IN DOTTED AREA EXCEPT THAT PRESET OUTPUT GOES TO PIN 6 OF P101 AND DETAIL NO.'S TO HAVE -15. EXP S101-1, V105-1, ETC.

ALL LAMPS 1/25 W NEON (S.E. N-2)

ALL VOLTMETERS MEASURED WITH VT VOLTMETER WITH COUNT AT ZERO.

CAPACITOR SPEC'S: VALUE GREATER THAN ONE----- $\mu$ F UNLESS NOTED OTHERWISE  
VALUE LESS THAN ONE----- $\mu$ F  
TOLERANCE----- $\pm 5\%$   
VOLTAGE RATING-----500 V  
RESISTOR SPEC'S  
POWER RATING-----1/2 W  
TOLERANCE----- $\pm 5\%$



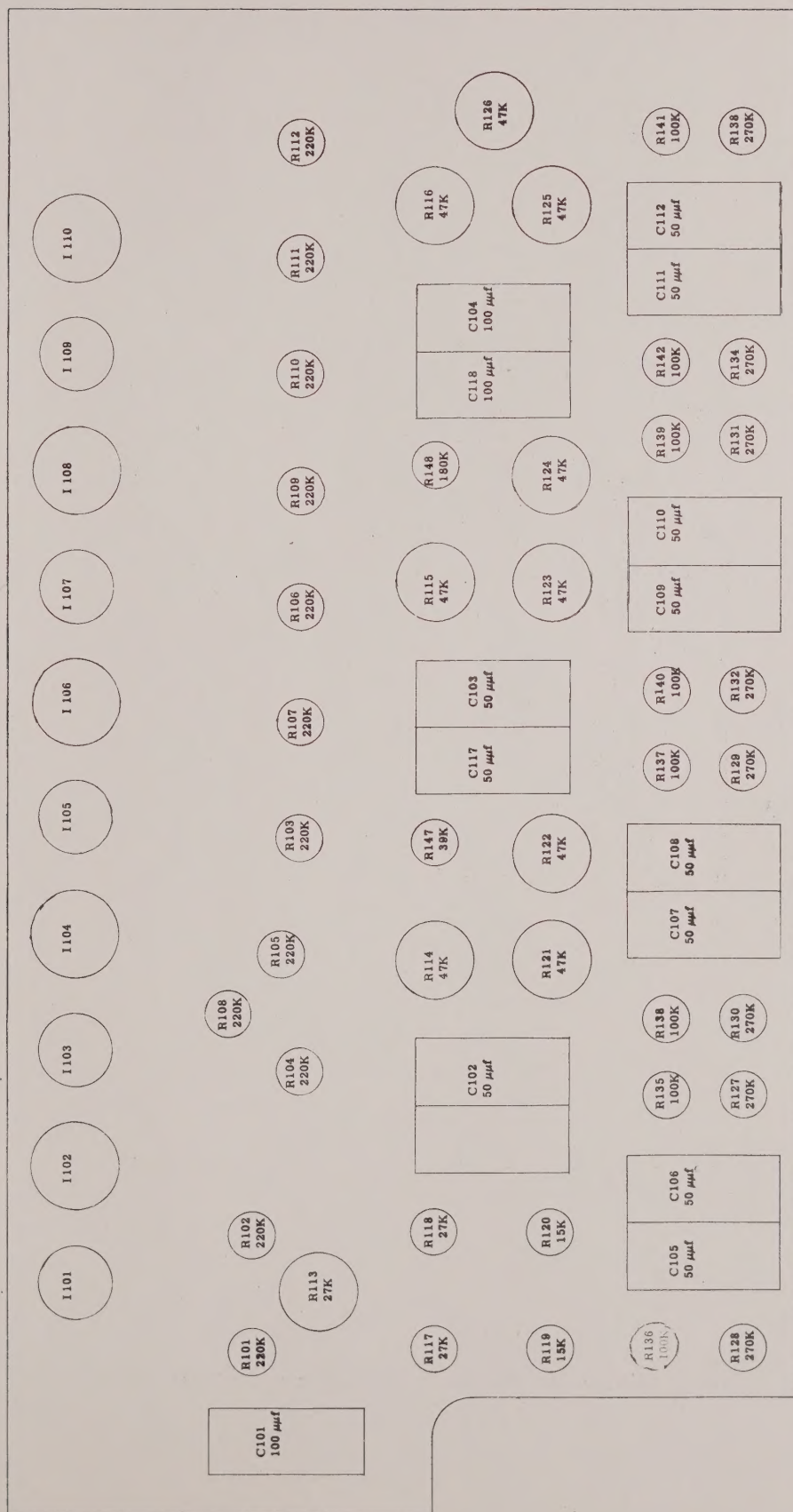
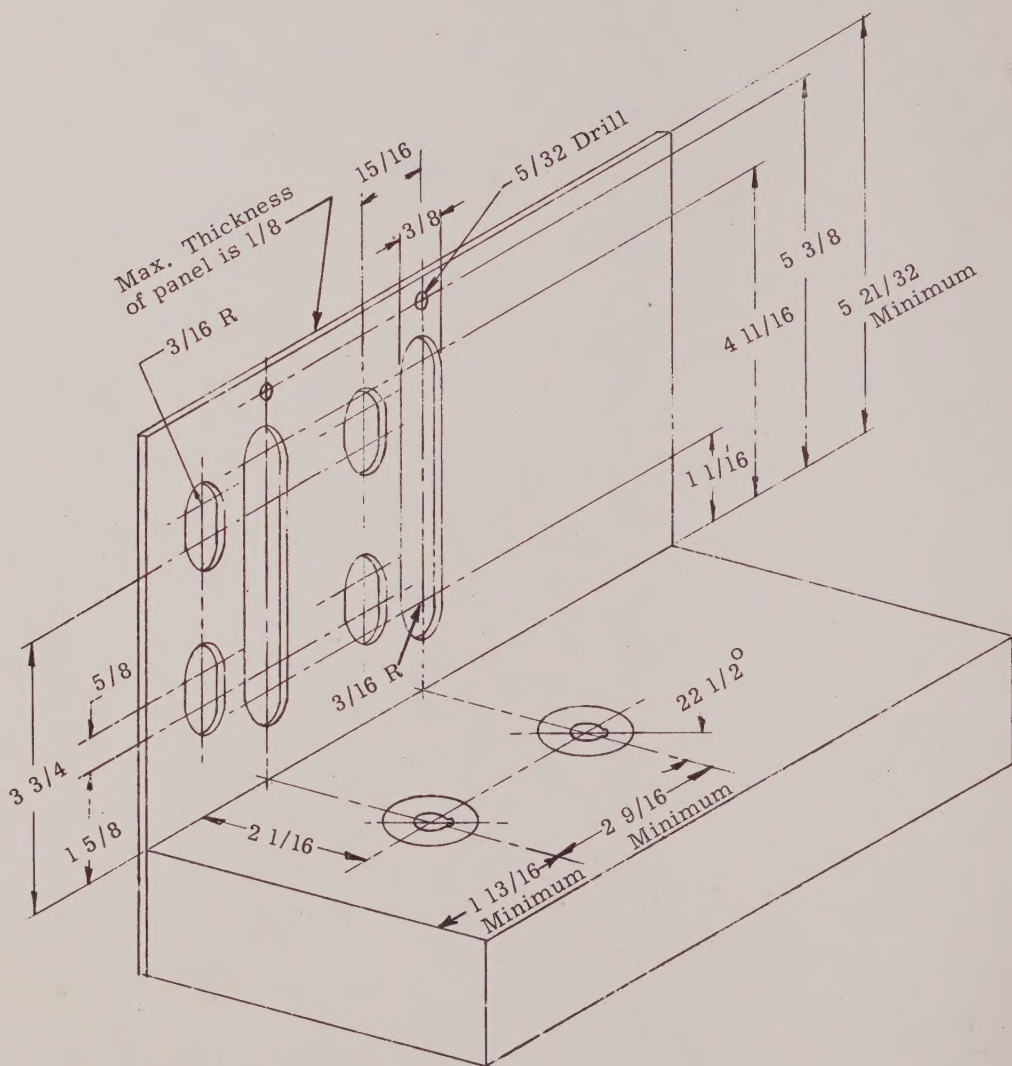


Figure 7 Parts Layout



NOTE: Dimensions are based on the use of Amphenol "MIP" sockets mounted above the chassis.

Figure 8 Mounting Dimensions, Model 732



